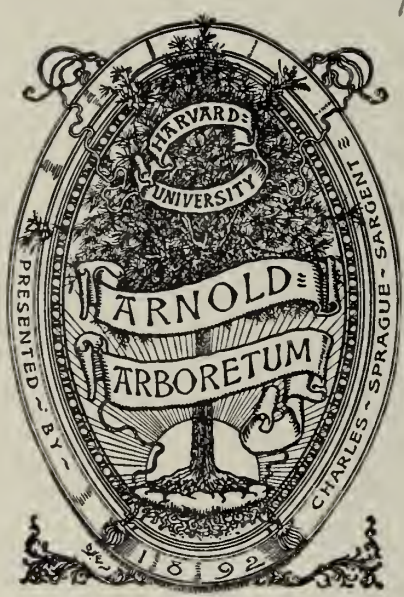
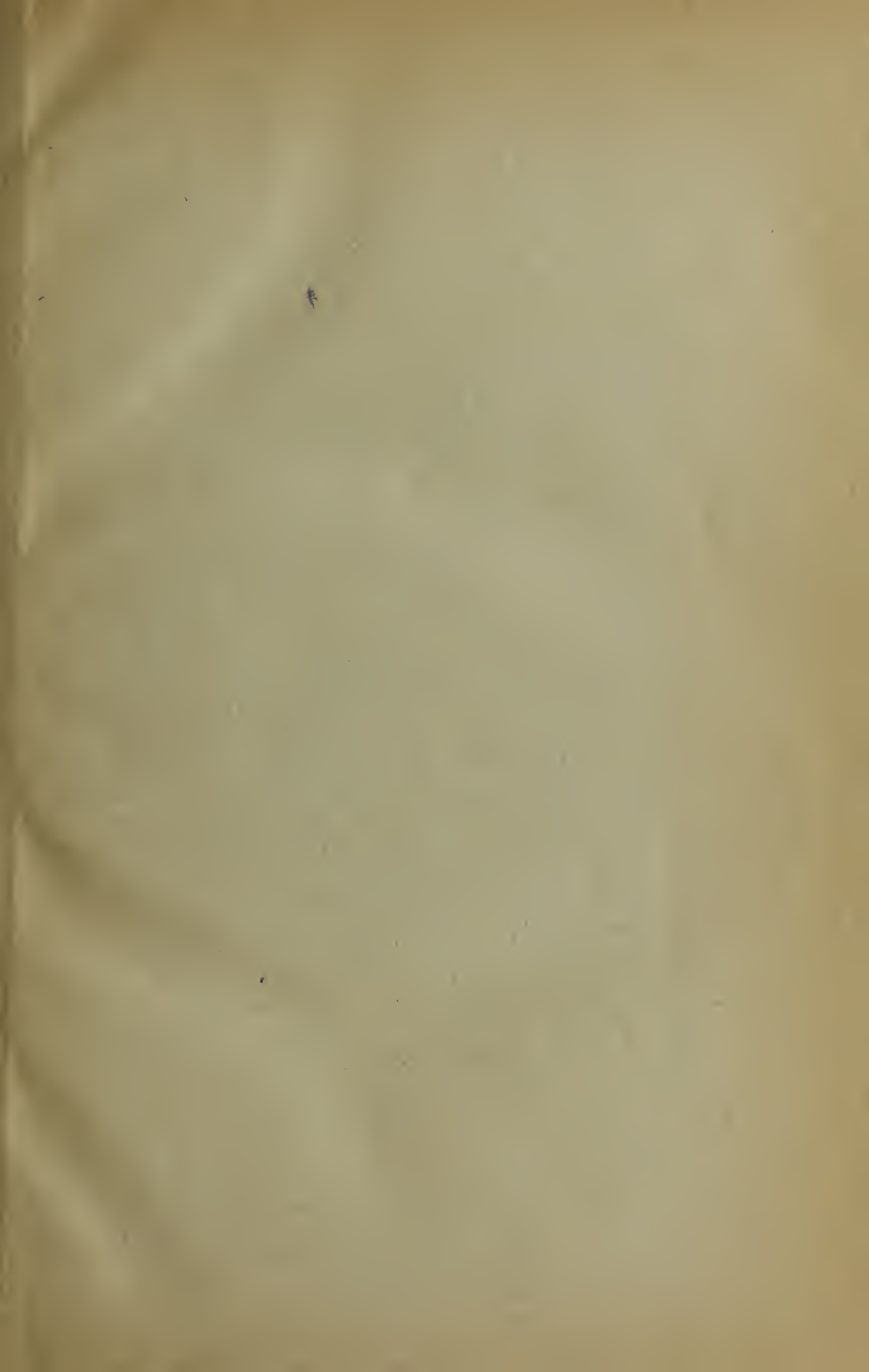


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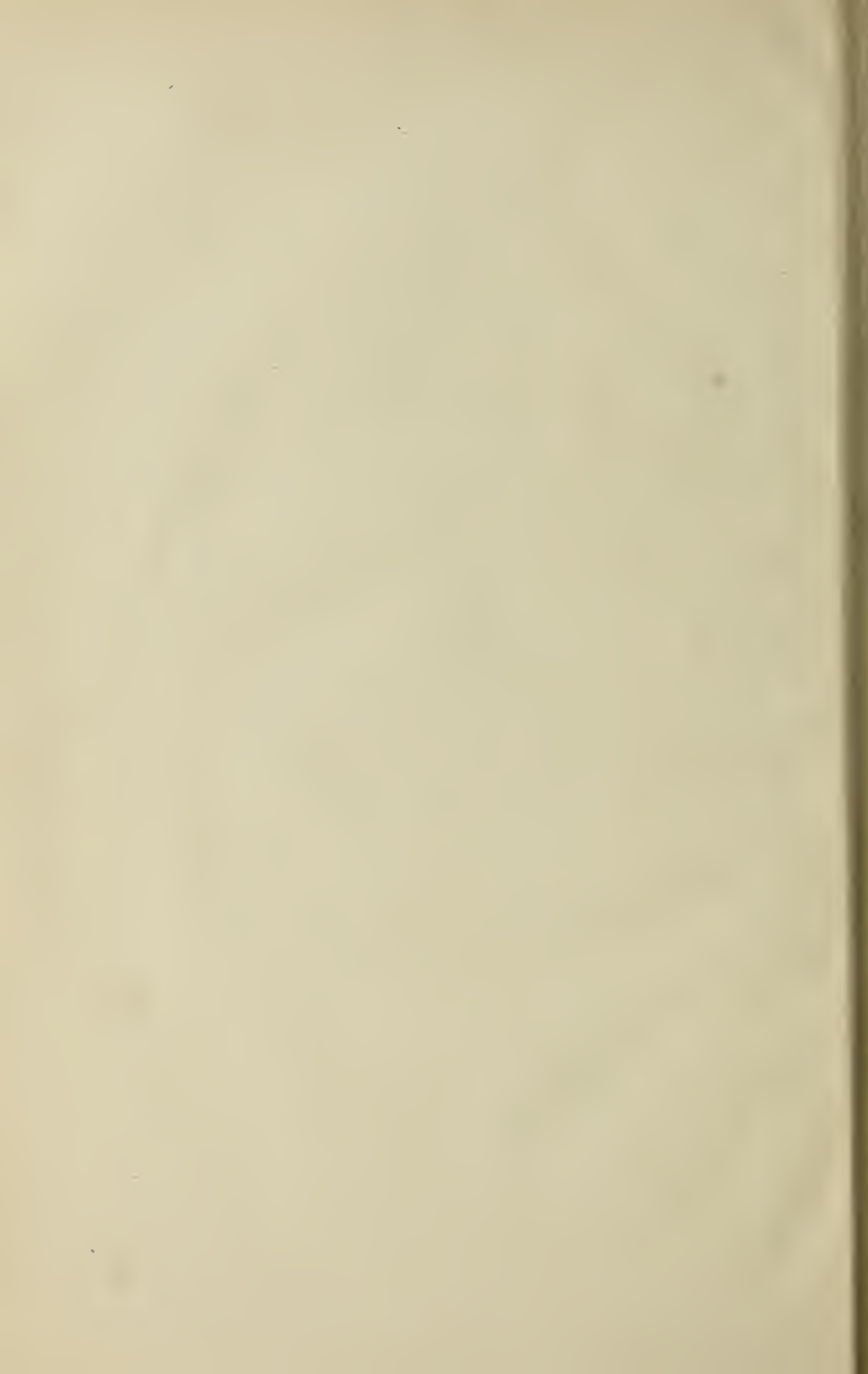








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THE  
INDIAN FOREST  

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RECORDS  

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VOLUME IX



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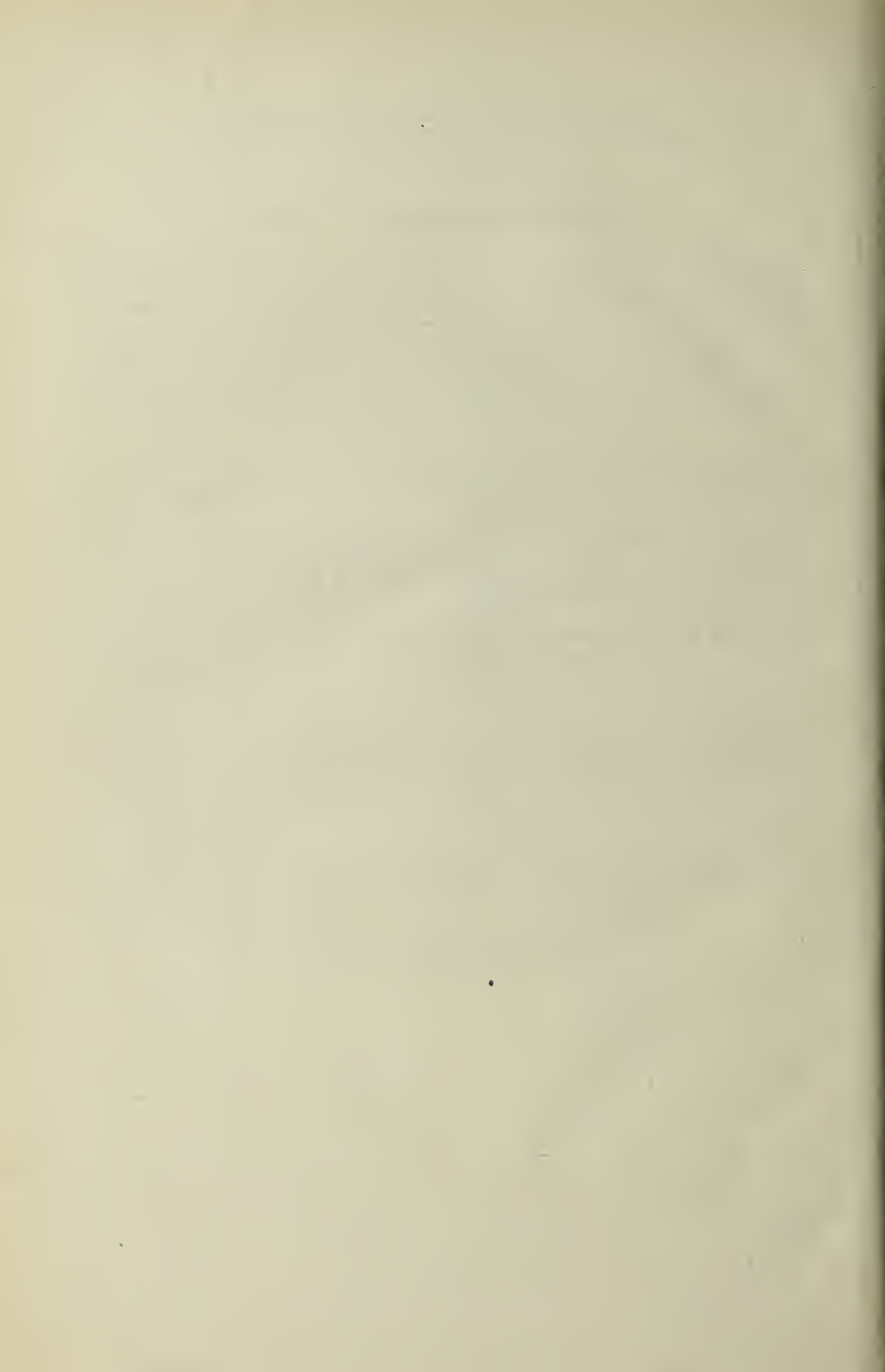
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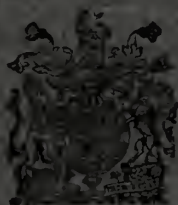
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**Note on the Indian Sleeper Market,  
Record of durability tests on Treated Sleepers  
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*Economist at the Forest Research Institute, Dehra Dun.*



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[Continued on page 3 of cover.]



VOL. IX

PART I

THE  
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**RECORDS**

#  
**RESULTS OF ANTISEPTIC TREATMENT OF  
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**Note on the Indian Sleeper Market,  
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## INTRODUCTION.

THE following Forest Record is the third dealing with the experiments carried out in connection with the Antiseptic Treatment of Sleepers ; Volume III, Part II, dealt with laboratory experiments carried out in 1910 ; Volume VI, Part IV, dealt with the field experiments and recorded the state of the sleepers laid in the lines up to 1917. The oldest field experiments having been in progress nine and a half years, this Record—

- (i) deals with the present condition of the sleeper market ;
- (ii) records the state to date of the different species of sleepers treated by four processes ;
- (iii) discusses the results obtained, and
- (iv) briefly reviews the conclusions arrived at from these experiments.

The writer's best thanks are due to all Railway Officers who have most carefully looked after the experimental sleepers laid in the different lines and for their unfailing assistance when carrying out the annual inspections.





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PEARSON:—RESULTS OF TREATED SLEEPERS.



Photo-Mech. Dept., Thomason College, Roorkhee.

Howellized 'Suii' *Termitia tementosa* B. G. sleepers laid in the Laksar-Hardwar section of the Oudh & Rohilkhand Railway, showing their condition after having been 9 years in the line.



# INDIAN FOREST RECORDS

Vol. IX. ]

1922

Part I

## RESULTS OF ANTISEPTIC TREATMENT OF SLEEPERS.

**Note on the Indian sleeper market, Record of durability tests  
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by

R. S. PEARSON, C.I.E., I.F.S.,

*Economist at the Forest Research Institute, Dehra Dun.*

### PART I.

**General review of the position of the sleeper market in India.**

#### 1. DISCUSSION ON SLEEPERS BY THE RAILWAY BOARD AND ENGINEERS IN 1921.

At a meeting of the Railway and Forest Officers held in 1919, a discussion on Railway Sleepers took place, the substance of which was recorded in paragraph *xvi* of the proceedings. Mr. Harvey, the then Chief Engineer, North Western Railway, discussed the question of supplies from Kashmir, the Punjab and Burma and also referred to the creosoting plant to be erected by his railway near Bias. This subject was again discussed at a meeting of the Chief Engineers in April 1919 and further discussion as to ways and means of increasing the supply of sleepers was taken up at a meeting of Chief Engineers held early in August 1921, when the following minutes were recorded :—

“On Tuesday, 2nd August, Mr. R. S. Pearson, Forest Economist, presented a note on the antiseptic treatment of sleepers and supplemented it with further remarks on the tests that had been carried out during the past ten years and on the present position. The note was discussed at some length, Mr. Pearson replying to many questions.

The general conclusions arrived at were :—

- (a) That, in view of the shortage of standard (*i.e.*, Sal, Deodar and Pyinkado) sleepers, it is necessary to supplement supplies with sleepers of treated second class timbers and of concrete, iron and steel.
- (b) That the economic possibilities of treated sleepers of second class timbers are very well worth further consideration. In particular *Terminalia tomentosa* (Asna, Sain, Mutti, Tauk-kyan, etc.) and all other *Terminalias* except *T. belerica* seem most promising ; also Chir, Spruce and several other varieties mentioned by Mr. Pearson.
- (c) That it is advisable to consider the possibilities of establishing pressure treating plants in suitable places either for one railway or for the combined requirements of two or more railways.
- (d) That for the successful employment of treated second class timbers as sleepers it is essential that the greatest care should be taken in seasoning the timber and in laying the sleepers heart upwards.

Mr. Richards promised to have Mr. Pearson's note, with additions which Mr. Pearson kindly undertook to provide, printed as a " Technical Paper."

## 2. PRESENT CONDITIONS IN THE SLEEPER MARKET.

The present condition of the sleeper market may be summarised by stating that the supply of standard sleepers, such as teak, deodar, sal and Pyinkado, is not sufficient to meet the demand, with the result that not only have prices been forced up to double pre-war rates but that the Railway Engineers do not know where to turn for supplies to meet their requirements. The position is therefore a serious one, and has led to forcing the railways to import foreign sleepers, to consider the more extensive use of iron and concrete sleepers and to utilize species of timber other than standard kinds, which in some cases hardly meet their requirements. The cause of this shortage of standard sleepers is not far to seek. Merchants find it more profitable to convert timber into forms other than sleepers ; then again, during the war faulty sleepers were not replaced at the same rate as in normal times, resulting in much leeway having to be made up to make good the deficit and lastly, to the difficulty in obtaining iron sleepers. If a reference is made to Appendix I, it will be seen that the average annual purchases made by the Railways during the last ten years amount to 3,238,616 sleepers, many of which

were of other than standard species, namely teak, deodar, sal and Pyinkado. This position of affairs clearly points to the fact that the supply of standard sleepers is insufficient to meet the demand and if further proof is necessary it can be seen in the prices of sleepers at the present time, an idea of which can be gathered by glancing at the graphic curves of sleeper prices shown in Appendix VIII. Another point which has to be taken into consideration is that the number of sleepers purchased annually during the last decade in no way represents the actual requirements of Indian Railways, as the war was in progress during that period. It is estimated that the present urgent requirements of all railways together is approximately three times the purchases made since 1911. To overcome the shortage and so as to increase the number of available sleepers, the Chief Engineers at their recent meeting proposed treating Indian hardwoods, and this is without doubt the solution to the problem.

### 3. PRICE OF SLEEPERS.

Attached to this note are graphic curves (Appendix VIII), showing the prices of sleepers since 1907, with the corresponding price of constructional timber at the present time. A study of this diagram will explain the reason for stating above that timber merchants find it more profitable to convert timber into scantlings and rafters than into sleeper sizes. The position of 'Pyinkado' in Burma is most marked in this respect.

#### (i) 'Deodar,' *Cedrus Deodara*.

First class 'Deodar' Broad Gauge sleepers are now selling at from Rs. 8-4-0 to Rs. 9-8-0 at Jagadhri, Hardwar and Lahore, whereas in September 1907 they were selling at Rs. 3-2-0.

#### (ii) 'Chir,' *Pinus longifolia*.

In December 1916, 'Chir' Broad Gauge sleepers were fetching from Rs. 2-4-0 to Rs. 2-6-0, whereas they are now realising from Rs. 3-10-0 to Rs. 4-0-0 at Jagadhri and Hardwar.

#### (iii) 'Kail,' *Pinus excelsa*.

Broad Gauge 'Kail' sleepers are selling at Rs. 5-0-0 to Rs. 5-8-0 at Jagadhri and those from the Bashahr Division have recently been sold at Rs. 7-0-0.

(iv) 'Sal,' *Shorea robusta*.

Nepal 'Sal' Broad Gauge sleepers fetched Rs. 4-12-0 in 1907, the price has steadily risen since then to from Rs. 7-8-0 to Rs. 9-0-0. Indian 'Sal' was sold for Rs. 3-12-0 to Rs. 3-14-0 in 1906, whereas now a Broad Gauge sleeper fetches Rs. 6-0-0.

(v) 'Pyinkado,' *Xylia dolabriformis*.

Metre Gauge sleepers are sold to the Burma Railways at from Rs. 2-0-0 to Rs. 2-5-0, whereas 'Pyinkado' scantlings fetch Rs. 4-7-0 for 1.5 c.ft. which is equal to the amount of timber contained in a Metre Gauge sleeper.

(vi) 'Rai,' *Picea Morinda*.

Broad Gauge sleepers are now quoted at Rs. 3-8-0 at Jagadhri and Rs. 3-4-0 by the Bashahr Division, whereas before the war there was practically no demand for this class of timber.

(viii) 'Sain,' *Terminalia tomentosa*.

'Sain' is quoted at Rs. 1-4-0 per c. ft. by the Manager, Clutterbuckganj, which is equal to about Rs. 3-12-0 per Broad Gauge sleeper, while the Burma Railways are paying about Rs. 1-10-0 per Metre Gauge sleeper.

## 4. SUPPLIES OF SLEEPERS.

(i) 'Sal,' *Shorea robusta*.

Some years ago a detailed statement was prepared of all 'Sal' sleepers supplied annually to the railways of India, which showed that the average consumption of Broad Gauge sleepers was 473,600 and of Metre and Narrow Gauge sleepers 657,880 or approximately 56,660 tons per annum.

(ii) 'Pyinkado,' *Xylia dolabriformis*.

Very large quantities of 'Pyinkado' are available in Burma, but export presents difficulties, especially as this timber fetches much better prices when cut into posts, scantlings, rafters, etc., than when converted into sleepers. On the other hand it is one of the finest sleeper woods in the world, being as durable if not more so, than Nepal Sal. To obtain supplies of Broad Gauge sleepers from Burma would entail paying a relatively high price, equal to, if not higher than, that now paid for



Nepal 'Sal.' Figures of actual outturn obtained from Burma, are as follows :—

Name of Circle.	From Reserved Forest, in tons.	From Unclassed Forest, in tons.	Total, in tons.
Northern Circle . . . .	205	10,284	10,389
Southern Circle . . . .	9,473	785	10,266
Pegu Circle . . . . .	5,600	18,735	24,335
Tenasserim Circle . . . .	2,302	23,571	25,878
		TOTAL .	70,868

(iii) 'Deodar,' *Cedrus Deodara*.

The supplies of Deodar timber are mainly obtained from the United Provinces, the Punjab, the North-West Frontier Province and Kashmir, of which the majority of the sleepers are taken up by the Railways. The annual outturn of 'Deodar' from the United Provinces is roughly 500,000 c.ft. ; that from the Punjab 4,141,600 c.ft., or 1,361,000 c.ft. of sleepers, 1,235,000 c.ft. of logs, and 90,000 c.ft. of scantlings. It is not possible to state the exact amount of 'Deodar' available from the North-West Frontier Province, though in 1919-20 174,840 c.ft. of 'Deodar' were in stock in the sale depôts. The Simla Hill States produce approximately 311,100 c.ft., while Kashmir produces 3,000,000 c.ft. per annum, of which 2,500,000 c.ft. are in the form of sleepers.

(iv) 'Chir,' *Pinus longifolia* and 'Kail,' *Pinus excelsa*.

'Chir' is obtained from the Punjab, United Provinces, North-West Frontier Province, Kashmir, the Simla Hill States and Tehri State. It is not known how much 'Chir' timber is extracted from the forests of the United Provinces, as the outturn of Silver fir, Spruce and Kail (*Pinus excelsa*) are grouped together with that of 'Chir.' The total outturn of these four species amounted to 2,764,753 c.ft. in 1919-20, of which 'Chir' made up the greater portion. The outturn from the Punjab is also not accurately known ; 74,300 c.ft. of pine logs were extracted in 1919-20, and 1,872,600 c.ft. of sleepers other than 'Deodar,' a large proportion of which were 'Chir.' In the North-West Frontier Depôts about 28,000 c.ft. of timber were in hand at the close of 1919-20. Kashmir provides 250,000 c.ft. per annum and 1,000,000 c.ft. of 'Kail,' and the Simla Hill States about 36,300 c.ft. of 'Chir' and 341,450 c.ft. of 'Kail' timber.



## (v) 'Spruce' and 'Silver Fir.'

The quantity of these timbers available from the Punjab, United Provinces, North West Frontier Province and Kashmir is very large. The total quantity which might be forthcoming is not known, as it is only in recent years that in response to a demand, these timbers have been exploited in quantity. The tendency is now to work the forests containing 'Spruce' and 'Silver Fir' to a much greater extent than formerly. Kashmir for instance produces 1,000,000 c.ft. of which 50,000 c.ft. are sleepers and once the market is ensured and a steady demand arises there can be no doubt that the supply will be very large. The rising demand is indicated by the fact that the North-West Frontier Depôts had stocked as much as 190,000 c.ft. of these timbers in 1919-20, while the outturn from the Simla Hill States amounts to 22,340 c.ft. per annum.

(vi) 'Sain,' *Terminalia tomentosa*.

Large quantities of this timber are available from Burma, as it is common in that Province and has been little extracted in the past. The quantity available is not known, though, were the forests to be worked systematically, the annual yield would run into many thousands of tons. Supplies could be obtained from all the Pegu Yoma Divisions at from Rs. 60 to Rs. 70 per ton converted f.o.r. or about Rs. 5-0-0 per Broad Gauge sleeper. In the Central Provinces, 'Sain' trees hardly grow large enough to convert into Broad Gauge sleepers, though a considerable number of Metre Gauge sleepers could be supplied. The amount annually available from the United Provinces is fixed at 402,000 c.ft. of which 281,000 c.ft. were extracted in 1919-20. The quantity taken out from the Bombay Forests per annum is about 73,000 c.ft. and this amount could be considerably increased, were a steady demand to arise. In Bengal the 'Sain' is not very common, but considerable supplies could be procured from Bihar and Orissa, especially from the Angul, Singhbhum, Cuttack and Sambalpur forests. The West Coast forests of Madras contain large quantities of this timber, especially the North and South Malabar and South Coimbatore divisions; the present outturn from these three divisions amounts to 33,000 c.ft. As in Bombay the outturn would be greatly increased, were a steady demand to arise. 'Sain' is plentiful in Mysore from which forests about 83,000 c.ft. are taken out annually, which is by no means the total quantity available; the Coorg forests also contain this species, some 10,000 c.ft. being put on the market every year.

(vii) 'Kindal,' *Terminalia paniculata*.

A tree confined to the West Coast and Southern Deccan from Goa southwards. It is much more plentiful than 'Sain' and similar in strength and structure to that timber. Figures of outturn are not available, though probably from 300,000 to 400,000 c.ft. would be available annually from the Kanara and Malabar Divisions, at about 25 per cent. below 'Sain' rates. The use of 'Kindal' for sleeper treatment presents a sound proposition, which deserves far more attention than has been given it in the past.

(viii) 'Hollock,' *Terminalia myriocarpa*.

A timber found in the North-East of Assam, growing in very fine stands. This species has not been worked much in the past, so that very considerable quantities are available. Were a demand to arise, there would be little difficulty in gradually working up to an outturn of from 100,000 to 150,000 Metre Gauge sleepers per annum.

(ix) 'In,' *Dipterocarpus tuberculatus*.

Mr. Troup writing in Forest Pamphlet No. 13, dealing with 'In' timber, states that probably at least 70,000 tons of 'In' timber are extracted annually from Burma. He further states that future supplies will depend largely on the steps taken to protect 'Indaing' forests and on the developments of forest roads. He estimates that the quantity of 'In' available for export for many years will be well over 50,000 tons per annum.

(x) 'Gurjan,' *Dipterocarpus turbinatus*.

'Gurjan' timber is found in large quantities in Burma, the Andamans, the Chittagong Hill Tracts and on the West Coast. Figures are not to hand as to the supplies available, though they are known to be very considerable.

(xi) 'Kanyin,' *Dipterocarpus alatus*.

Some time ago figures were collected as to supplies of 'Kanyin' available for treatment, which show that the Pyinmana Division could supply some 150,000 Broad Gauge sleepers for 5 years, and that the Rangoon Division could supply 20,000 Metre Gauge sleepers annually for the same period. The Tenasserim Circle of Burma could supply 2,000 tons or more annually, while it is estimated that were the four *Dipterocarpus* found in the Andamans to be worked, and sawmills, labour and shipping available, as many as 300,000 Broad Gauge sleepers could be supplied annually.

(xii) 'Hollong,' *Dipterocarpus pilosus*.

'Hollong' is found in the Assam forests to the east of the Assam-Bengal Railway, in the Sibsagar and Lakhimpur Divisions and also in the Frontier Tract Forests. It also occurs in the Chittagong Hill Tracts, Arakan and North Burma. It grows to a very fine tree in North Assam, with a clean cylindrical bole, rising to 60 feet and more to the first branch. It is estimated that the forests of Assam could produce upwards of 500,000 Metre Gauge sleepers annually, though to obtain this quantity would entail several years organisation, supported by funds for roads and more up-to-date methods of conversion.

## PART II. Record of Durability Tests on Treated Sleepers.

The main object of this note is to record the results of sleepers treated by different processes and laid in the line to carry out durability tests. The experiments were started in 1909 and the first sleepers were laid down in 1911. In 1912 a preliminary note \* was compiled on the subject, and in Chapter IV is outlined the scheme according to which it was proposed to carry on the experiments. In 1918 a further note † was published, detailing the various methods of treatment and recording to date the condition of the sleepers laid in the open lines.

### (1) DETAILS OF EXPERIMENTS.

In Appendices I to VI of this note are recorded the latest reports on the condition of the sleepers. It is not here necessary to review in detail the method and cost of treatment, as that information is recorded in previous reports. It is only necessary to consider the latest results available. The five species selected for durability tests were *Pinus longifolia* (Chir), *Pinus excelsa* (Kail), *Dipterocarpus tuberculatus* (In), *Dipterocarpus alatus* (Kanyin) and *Terminalia tomentosa* (Sain). The sleepers were laid in lines running through every condition of climate from excessively dry and hot to moist warm localities and were subjected to all types of traffic and conditions of metalling. The sleepers were treated according to four different methods, and the preservative introduced either in open tank or under pressure. An extension to the original scheme of experiments was carried out by treating a variety of Assam timbers in pressure and open tanks.

### (2) RESULTS WITH POWELLIZED SLEEPERS.

(For details of durability see Appendix I and for details of treatment see Forest Records, Vol. VI, Part IV, pp. 21 to 34.)

The sleepers have now been 9 to 10 years in the lines, and it should be noted that they were not in any way selected before treatment, otherwise the results might have been even better than is now the case

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\* Indian Forest Records, Volume III, Part II. Note on the Antiseptic Treatment of Timbers in India, with special reference to Railway sleepers. March 1912.

† Indian Forest Records, Volume VI, Part IV. A Further note on the Antiseptic Treatment of Timber recording results obtained from past experiments. 1918.



Then again, at the time they were laid down it was not known that in the case of the Pines infinitely better results could be obtained by laying treated sleepers heart up and sap down, instead of *vice versâ*, a point very clearly brought out by these experiments. It has also been found that dog-spikes gave better results than screw spikes with treated sleepers.

(i) *Powellized 'Chir.'*

The 'Chir' *Pinus longifolia* Powellized sleepers were laid in five different localities, of which two are dry, two moderately so and one is a wet area. In the two dry and one moderately dry localities the sleepers are still doing well; those near Cawnpore have lasted 9 years and will have to be removed in another couple of years, while those in the very wet locality on the Eastern Bengal Railway have failed after 9 years. From the results to date it is fairly certain that Powellized 'Chir' sleepers will last from 9 to 12 years according to locality and conditions of running, and probably longer if more care is taken in the selection and laying of the sleepers in the first instance.

(ii) *Powellized 'Kail.'*

The 'Kail' *Pinus excelsa* Powellized sleepers were laid in the same localities as the above mentioned 'Chir' sleepers. If reference is made to the percentage table at the end of Appendix I, it will be seen that on the whole 'Chir' have done better than 'Kail' sleepers. These figures, however, are somewhat misleading as the more unfavourable results in the case of 'Kail' are due to a large number of this species being laid in the very wet section on the Eastern Bengal Railway. In reality 'Kail' have generally done slightly better than 'Chir,' but hardly sufficiently so to compensate for the extra cost of the former. The first batch have failed after 9 years, while those laid in drier localities are expected to last 13 years or possibly longer.

(iii) *Powellized 'In.'*

'In' *Dipterocarpus tuberculatus*, Powellized sleepers were laid in the wet locality near the Naihati station of the Eastern Bengal Railway. They have now been in the line  $9\frac{1}{2}$  years and will probably have to be removed in a year or two. They have behaved in a rather curious way, as nearly all of them are sound at the ends and throughout the middle and have only deteriorated under the rail seat and round the spike hole. These sleepers were laid without bearing plates and will last 10 or 11 years, there can be little doubt that were plates used their life would be considerably increased.





Photo-Mech. Dept., Thomason College, Roorkee.

Powellized 'Chir' *Pinus longifolia* B. G. sleepers laid in the Laksar-Hardwar section of the Oudh & Rohilkhand Railway, showing their condition after having been in the line about 9 years.

[To face page 10.









Photo-Mech. Dept., Thomason College, Roorkee.

Powellized 'Kail' *Pinus excelsa* B. G. sleepers laid in Laksar-Hardwar Section of the Oudh & Rohilkhand Railway,

showing their condition after having been about 9 years in the line.

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(iv) *Powellized 'Kanyin.'*

'Kanyin' *Dipterocarpus alatus*, Powellized sleepers. The 'Kanyin' sleepers were also laid near Naihati station, in continuation of the 'In'. The same remarks apply to these sleepers as to the above, only that deterioration is somewhat more marked. Their life will be 10 years, which could be prolonged were bearing plates used.

(v) *Powellized 'Sain.'*

'Sain' *Terminalia tomentosa* Powellized. The 'Sain' sleepers were laid in the same five localities as the 'Chir' and 'Kail,' and are doing well. After  $9\frac{1}{2}$  years, 86 per cent. of the sleepers are still in A and B classes and only  $5\frac{1}{2}$  per cent. have been rejected. They are also standing the more trying climate and heavy conditions of running on the Eastern Bengal Railway far better than the other species under experiment. They are generally an ugly looking lot of sleepers, as they were never passed and are full of original defects. This timber is extremely hard and requires no bearing plates, while the spike holds well.

## (3) RESULTS OF SLEEPERS TREATED IN OPEN TANKS WITH AVENARIUS CARBOLINEUM OIL.

(For details of durability see Appendix II and for detail of treatment and cost see Indian Forest Records, Vol. VI, Part IV, pp. 34 and 35.)

The sleepers treated with *Avenarius Carbolineum* oil have been from seven to eight years in the line. The oil is expensive but highly toxic; the idea of treating them in this way with small quantities of a good grade oil was to save expense. The sleepers have done fairly well, especially the 'Sain'; so far the experiment indicates that it is on the whole false economy to spare the antiseptic solution when treating sleepers which will be exposed to so drastic conditions as are generally found in India. Appendix II gives in detail the results to date, a summary of which is as follows:—

(i) 'Chir' treated with *Avenarius Carbolineum* oil.

*Pinus longifolia*, 'Chir,' sleepers treated with *Avenarius Carbolineum* oil were laid in the Saharanpur District, North Western Railway,  $7\frac{1}{2}$  years ago. They are now rapidly deteriorating from dry rot, due probably to insufficient penetration of the oil, which amounted to only 4 lbs. per sleeper. There is no sign of white ant attack though the sleepers are badly cracking which would admit of their penetrating beyond the impregnated tissue. It is evident that heavier impregnation is necessary to protect 'Chir' sleepers.



(ii) 'Kail' sleepers treated with *Avenarius Carbolineum* oil.

*Pinus excelsa* 'Kail' sleepers were laid in continuation of the above mentioned 'Chir.' These sleepers are still doing well after  $7\frac{1}{2}$  years service, there is no sign of white ant attack or of rot having set in, though the oil absorbed only amounted to 4 lbs. The difference in the condition of the 'Chir' and 'Kail' is much more marked in this experiment than it was in the case of the Powellized sleepers, where 'Kail' had only a slight advantage over the 'Chir.'

(iii) 'In' sleepers treated with *Avenarius Carbolineum* oil

*Dipterocarpus tuberculatus*, 'In', sleepers were laid in three different localities in the Burma Railways, one being in the plains near Pyinmana, the other two on the hill section between Mandalay and Maymyo. They are Metre Gauge sleepers and absorbed only 1.1 lbs. per sleeper, which might be presumed would be insufficient to protect the timber, and as a matter of fact probably is so, though the sleepers are still doing fairly well, after being in the line for seven and a half years. A warning note is sounded in the report on these sleepers as to deterioration setting in round the spike hole, which it will be remembered has been recorded in the case of the Powellized 'In' sleepers laid in the Eastern Bengal State Railway and which may be the ultimate cause of failure. From results obtained in all experiments with 'In' timber there can be little doubt that boring and adzing before treatment and the use of bearing plates will considerably increase the life of this type of sleeper.

(iv) 'Kanyin' sleepers treated with *Avenarius Carbolineum* oil.

The 'Kanyin' sleepers treated with *Avenarius Carbolineum* oil, are fast deteriorating after being seven and a half years in the line, as 45 per cent. have already been rejected. The cause of rejection is decay round the spike hole and under the rail seat, but as those laid outside Maymyo are reported in some cases to be mere shells it is certain that owing to insufficient penetration of the antiseptic, white ants have been able to penetrate beyond the impregnated layer, and so destroy the sleepers.

(v) 'Sain' sleepers treated with *Avenarius Carbolineum* oil.

These sleepers are laid in three localities on the Robilkund and Kumaon Railway and are still doing well after being in the line seven and a half years. As many as 89 per cent. of the sleepers are in classes

A and B; 2 per cent. in class C and 9 per cent. rejected, the latter chiefly due to original defects, as these sleepers were not passed before treatment. The more favourable results with this class of sleeper are no criterion as to the value of the treatment, and cannot be until the sleepers have been a further period of two or three years in the line, as 'Sain' sleepers have been known to last up to 7 years in an untreated state.

(4) RESULTS OF SLEEPERS TREATED IN OPEN TANKS WITH CHLORIDE OF ZINC AND GREEN OIL OR AVENARIUS CARBOLINEUM.

(For details of durability see Appendix III and for details of Treatment and Cost see Indian Forest Records, Vol. VI, Part IV, pp. 45 to 57.)

The sleepers were treated first with a 2 per cent. solution of Chloride of Zinc of which a Broad Gauge sleeper absorbed 14 to 16 lbs. and after drying out were treated with from  $3\frac{1}{2}$  to  $4\frac{1}{2}$  lbs. of a high grade Creosote Oil. These sleepers have now been from seven to seven and a half years in the line. The idea of treating sleepers with a soluble toxic salt, which, however, is liable to be leached out of the timber by excessive moisture and then to prevent this tendency by giving them a coating of creosote, is one of economy. The salt used is cheap and as only small quantities of creosote are used, the combined process is considerably less expensive than the full cell creosoting process and even cheaper than the Rüpenising sleepers. The value of this process will be discussed later under 'Conclusions.'

(i) 'Chir' sleepers treated with Chloride of Zinc and Green Oil.

The 'Chir' sleepers were treated at Jagadhri and laid in the line near Muradnagar on the North Western Railway and have been down  $7\frac{1}{2}$  years. They are already beginning to fail due to splitting and rot, the former defect may in part be due to over heating during treatment and partly to having been a poor lot of sleepers when taken over for treatment. There is, however, no sign of white ant attack, on the other hand 13 per cent. have been rejected to date and 19 per cent. are in C Class.

(ii) 'Kail' sleepers treated with Chloride of Zinc and Green Oil.

The 'Kail' sleepers are laid in continuation of the above, and are doing well, being originally a better lot of sleepers than the 'Chir.' Only 3 per cent. have been rejected, while 9 per cent. are in C Class. The spikes are holding well, the rail cut is insignificant and there are no signs of white ant attack.

## (iii) 'In' sleepers treated with Chloride of Zinc and Green Oil.

The 'In' sleepers were laid in two localities, one near Pyinmana and the other north of Myingyan, on the Burma Railways. So far the results are not nearly so good as when 'In' is treated by other processes. They are, as noted elsewhere, deteriorating round the spike hole and under the rail seat. Dry rot is common and the sleepers are also developing large longitudinal cracks. The rejections and C Class sleepers already amount to 64 per cent., while the sleepers have been only just over 7 years in the line.

## (iv) 'Kanyin' sleepers treated with Chloride of Zinc and Green Oil.

The 'Kanyin' sleepers treated by this process are even worse than the 'In' sleepers and have nearly all failed in 7 years, as 72 per cent. have been rejected up to date and 11 per cent. are in C Class. The cause of deterioration is decay round the rail seat.

(v) 'Sain' sleepers treated with Chloride of Zinc and *Avenarius Carbolineum* Oil.

'Sain' sleepers were treated at Shahpur in Betul with a 2 per cent. solution of Chloride of Zinc, absorbing 12 lbs. of the solution, and after they had been allowed to dry out they were immersed in *Avenarius Carbolineum* oil for a short period, during which they took up 3 lbs. of the oil. The sleepers have been in the line  $7\frac{1}{2}$  years and have now nearly all been rejected which shows that this method of sleeper treatment is not suitable under Indian conditions. The chief cause of rejection is white ant attack, while when the sleepers were covered with ballast they were subject to dry rot.

## (5) RESULTS OF SLEEPERS TREATED WITH SOLIGNUM AND BURMA OIL OR LIQUID FUEL.

(For details of durability see Appendix IV and for details of treatment and cost see Indian Forest Records, Vol. VI, Part IV, pp. 57 to 68.)

The Pine sleepers were treated in open tanks at Jagadhri with a mixture of 40 per cent. of *Solignum* and 60 per cent. of Earth Oil. At the request of the North Western Railway, the writer also treated 50 Broad Gauge 'Deodar' sleepers in the same way. Nine pounds of this mixture was introduced on the average into each sleeper, though in some cases when treating highly seasoned 'Chir' this amount was considerably exceeded. The idea of mixing Earth Oil with the *Solignum* was to reduce the cost of treatment, which from the results obtained to date seems to be justified.

The *Dipterocarp* sleepers were treated at Pyinmana in Burma, by B. Gyan Singh, the writer's assistant. The solution used was two parts Earth Oil and one of *Solignum*, of which each Metre Gauge sleeper took up 4.7 lbs.

The *Terminalia tomentosa* sleepers were treated at Shahpur in the Betul District with one part of *Solignum* and two parts of Earth Oil, each Broad Gauge sleeper taking up 9.77 lbs. of the mixture.

The Assam Hardwoods, of which details are given in Appendix IV, were treated at Jaipur, in the Lakhimpur Division of Assam, in 1915. The solution used was *Green Oil*, which is a good grade creosote, mixed with equal quantities by weight of Assam Earth Oil. The amount taken up varied from 0.5 lb. to 25 lbs. per Metre Gauge sleeper, according to species. These experiments were supplemented at the same time by treating sleepers under pressure at Digboi, details of which are given in section 6.

*'Chir' sleepers treated with a mixture of 40 per cent. Solignum and 60 per cent. Earth Oil.*

The 'Chir' sleepers were laid in three separate places on the Ferozepur-Macleodganj Section of the North Western Railway in November 1914. They were last inspected at the end of May 1921, and have therefore been  $6\frac{1}{2}$  years in the line. None have been rejected to date, while 86 per cent. are in classes 'A' and 'B' and 14 per cent. in class 'C.' The rail-cut is insignificant under the bearing plate, while there are slight signs of white ant attack in two cases. The sleepers may therefore be said to be doing well, though how much longer they will last cannot at present be estimated.

*'Kail' sleepers treated with a mixture of 40 per cent. Solignum and 60 per cent. Earth Oil.*

The 'Kail' sleepers were laid at the same time in continuation of the above; 94 per cent. are in classes 'A' and 'B' and 6 per cent. in class 'C.' They are therefore doing slightly better than the 'Chir.'

*'In' sleepers treated with a mixture of 33 per cent. of Solignum and 67 per cent. of Earth Oil.*

The Metre Gauge 'In' sleepers treated at Pyinmana had been 6 years and 2 months in that section of the line at the date of the last inspection. Their condition is still good, though a few have been attacked to some extent by white ants. Of 470 sleepers laid down, 437



are in classes 'A' and 'B,' 5 in class 'C' and 28 have been rejected. The Engineer who carried out the last inspection states that they may still last 2 or more years.

*'Kanyin' sleepers treated with a mixture of 33 per cent. of Solignum and 67 per cent. of Earth Oil.*

Of the 500 'Kanyin' Metre Gauge sleepers laid in continuation of the above, 397 were in classes 'A' and 'B' at the time of the last inspection, 60 were in class 'C' and 43 had been rejected, after a little over 6 years. These sleepers are not doing quite so well as the 'In' sleepers referred to above.

*'Sain' sleepers treated with a mixture of 33 per cent. of Solignum and 67 per cent. of Earth Oil.*

The 'Sain' sleepers were laid in the Itarsi-Nagpur Section of the Great Indian Peninsula Railway 5 years and 11 months ago. When last inspected, out of 525 Broad Gauge sleepers laid down, 510 are in class 'A,' 7 in class 'B,' 6 in class 'C' and 2 have been rejected, these sleepers are therefore doing very well and may be expected to last several years longer.

*'Deodar' sleepers treated with a mixture of 40 per cent. Solignum and 60 per cent. of Earth Oil.*

The 50 'Deodar' sleepers treated at Jagadhri were laid down in continuation of the 'Chir' and 'Kail' sleepers in three localities on the Ferozepur-Macleodganj Section of the North Western Railway, some  $6\frac{1}{2}$  years ago. Of the total number laid down 90 per cent. are in classes 'A' and 'B' and 10 per cent. in class 'C,' and they have, therefore, given no better results to date than 'Chir' or 'Kail' treated under similar conditions and laid in the same locality.

*Assam hard woods treated with a mixture of equal parts of Green Oil and Assam Earth Oil.*

A few sleepers of each of five species were treated in open tanks at Jaipur in Assam, all of which are doing well. As these species are dealt with in detail in the next section, it is not here necessary to do so, especially as further detailed information is given in Appendix IV of this note.



## (6) RESULTS OF SLEEPERS TREATED UNDER PRESSURE WITH A MIXTURE OF GREEN OIL AND ASSAM EARTH OIL.

(For details of durability see Appendix V and for details of treatment and cost see Indian Forest Records, Vol. VI, Part IV, pp. 82 to 89.)

The original series of durability tests are complete with the above recorded experiments, and it was not until 1915 that the writer commenced another series of experiments in Assam. These experiments are virtually a continuation of group 5, with this difference that most of the sleepers were treated under pressure instead of in Open Tanks. Seven species were selected for treatment of which the greater portion were either 'Sida' (*Lagerstræmia parviflora*), 'Hollock' (*Terminalia myriocarpa*), 'Hollong' (*Dipterocarpus pilosus*) or 'Jutili' (*Altingia excelsa*): of the other three species only a few sleepers were treated. The majority of these sleepers were laid down towards the end of 1915 and the beginning of 1916 and so had been from 5 to 5½ years in the line at the date of last inspection.

(i) 'Sida' sleepers treated under pressure with *Solignum* and Assam Earth Oil.

*Lagerstræmia parviflora* or 'Sida' Metre Gauge sleepers, numbering 151, were laid in the line near Moriani on the Assam-Bengal Railway over five years ago, after being treated with equal parts of Earth Oil and *Solignum*. The exact quantity of the solution introduced is not known, as they were treated after the initial absorption tests had been carried out. It is known, however, that they were treated on the same lines as the 'Hollong' and 'Hollock' sleepers, about which reference will be made hereafter. They are not doing very well as the sleepers have a distinct tendency to crack, which is a common feature of this species of timber. On the other hand there are no signs of rot or white ant attack, which goes to prove the efficiency of the treatment.

(ii) 'Hollock' sleepers treated with Earth Oil and *Solignum*.

The 'Hollock' (*Terminalia myriocarpa*) sleepers were treated under pressure at Digboi, and absorbed from 5.3 lbs. to 8.6 lbs. per Metre Gauge sleeper, according to treatment. They were laid in the line over 5 years ago and are doing very well, as 93 per cent. of them are still in 'A' and 'B' classes, of which only 8 per cent. are in the latter. This timber is hard, close and clean grained and is in consequence somewhat difficult to treat, on the other hand it will probably be found to give an extremely useful sleeper after treatment.

(iii) 'Hollong' sleepers treated with Earth Oil and Solignum.

'Hollong' (*Dipterocarpus pilosus*), one of the commonest timbers of North Assam, lends itself easily to treatment. The 191 sleepers laid down in the line near Moriani nearly six years ago, were treated under pressure at Digboi, and absorbed 11.2 lbs. per sleeper in 15 minutes at 100 lbs. pressure. They were fairly seasoned before treatment, an important factor governing their future behaviour when laid in the line. The sleepers are doing well, there is no sign of white ant attack or rot setting in, while the spikes are holding well. The 6 per cent. of renewals are all due to cracking when the sleepers were first put in the line.

(iv) 'Sam' sleepers treated with Earth Oil and Solignum.

A few 'Sam' (*Artocarpus Chaplasha*) sleepers were treated and put in the line over five years ago. They are doing well as 85 per cent. are still in class 'A.' No defects were noticed at last inspection except a slight tendency to warp.

(v) 'Jutili' sleepers treated with Earth Oil and Solignum.

Some 65 'Jutili' (*Altingia excelsa*) sleepers were treated at Digboi, the amount of oil they absorbed is not known, though they were treated on the same lines as 'Hollong.' They were laid down from 4 to 5 years ago and with the exception of two sleepers, which are showing signs of dry rot, they are doing well in every respect.

(vi) 'Gahori Supa' sleepers treated with Earth Oil and Solignum.

Twenty-one 'Gahori Supa' (*Magnolia* Sp.) were treated under pressure and laid in the line over five years ago. The exact species of *Magnolia* to which this timber belongs is not known but it is probably *Magnolia Pealiana*. The sleepers with the exception of two rejected are doing well.

(vii) 'Ping' sleepers treated with Earth Oil and Solignum.

Eighteen 'Ping' (*Cynometra polyandra*) sleepers were treated at Digboi and laid in the line over five years ago. Two have been rejected, 14 are in 'A' Class and 2 in 'B' Class. This timber is very common up the Borak river and is scarcely ever used, due to its habit of splitting badly. From this very limited experiment, so far as can be judged at present, there seems to be a distinct possibility of utilising this timber for sleepers after treatment.

## (7) RECORD OF INDIAN SLEEPER WOODS CREOSOTED IN ENGLAND AND AMERICA, AND LAID IN THE LINES TO TEST THEIR DURABILITY.

(For details of durability tests see Appendix VI and for details of treatment and cost see Indian Forest Records, Vol. VI, Part IV, pp. 92 to 97.)

Fifty Metre Gauge and forty-six Broad Gauge 'Gurjan' (*Dipterocarpus turbinatus*) sleepers were sent home from the Andamians to Messrs. George Black and Sons of Berwick-on-Tweed for treatment. These sleepers absorbed 11 lbs. and 21 lbs. of Creosote per sleeper respectively, and after treatment were sent out to India and laid in the Eastern Bengal State Railway, about 5½ years ago. Both lots are in excellent condition, none have been rejected and none to date have failed under the rail seat, which may be anticipated when dealing with *Dipterocarp* sleepers, when laid without bearing plates. However, in this instance it is as yet too early to form an opinion as the sleepers have only been in the line a relatively short period of time.

(i) *Indian Spruce and Silver fir Creosoted in England.*

Six Spruce and six Silver fir Broad Gauge sleepers were sent home by Messrs. Millars' Timber and Trading Company and creosoted after which they were brought out again and laid in the Rohri Section of the North Western Railway. It would hardly be worth recording the above fact, which deals with so few sleepers, were it not that as far as is known this is the only instance of Indian Spruce and Silver fir sleepers having been creosoted and laid for durability tests in Indian Railways. The subject is of further interest as proposals have been made to treat these species of timber on an extensive scale. The sleepers were treated by the 'full cell' or 'straight' process and only took up very little creosote, as might have been expected. The Silver fir after a six-hour treatment absorbed 9½ lbs. and the Spruce 7½ lbs. per Broad Gauge sleeper. The writer inspected these sleepers and cut some open after they had been rejected and found the oil penetration very limited. Of the Silver fir, four were removed after 4 years and 9 months and two were still in the line after five years. The cause of rejection was white ant attack, the outside or impregnated portion being sound and the interior destroyed. Of the Spruce sleepers, one lasted about four years, four lasted 4 years and 9 months and one a little over 5 years; the rejections were solely due to white ant attack. The most interesting point about these experiments is that the rail cut after four to five years was insignificant and the spikes held well in both species, which, considering the texture and relatively softness of these timbers, is surprising. As stated above the cause of rejection was want of depth of penetration of the creosote and consequent

attack by white ants. These timbers are very similar in structure to Douglas Fir, which it is well known is difficult to treat, but which can be satisfactorily treated if first dealt with by incision machines and then boiled in vacuum. There appears no reason to doubt that Indian Spruce and Silver fir could be treated in the same way and provided proper penetration of the creosote is attained that these timbers may prove satisfactory.

(ii) *Douglas Fir Creosoted in America and sent to India.*

Two hundred creosoted Metre Gauge Douglas Fir sleepers were laid as an experiment in the Assam-Bengal Railway near Moriani in March 1916. The reason for mentioning this experiment is to draw attention to the striking results obtained by laying 100 sap up and heart down and 100 *vice versâ*. Of the former 2 sleepers remain in Class 'A,' 87 in Class 'B' and 11 in Class 'C,' while of those laid sap down and heart up 82 are in Class 'A' and 2 in Class 'B,' 5 in Class 'C' and 3 are rejected. The striking advantage of laying the sleepers sap down and heart up, corroborates the writer's contention, which is dealt with in detail on page 30 of Indian Forest Records, Vol. VI, Part IV, and of which an illustration is given on the opposite page of that report. The practice of Indian Engineers is to reverse the process in the case of untreated sleepers and to lay them heart down and sap up, which is undoubtedly correct, as untreated sapwood is far more likely to deteriorate than untreated heart wood. On the other hand there can be no doubt that with a treated sleeper it is best to lay sap down and heart up, and especially when dealing with pine woods, for the reason that the sap takes up more of the antiseptic than the heart and at the same time splits more if exposed to the sun, while with the heart up a harder bearing surface is presented for the rail seat and spikes.



**PART III. Discussion on results obtained by treating sleepers.**

A discussion on the results obtained in the experiments dealt with in the preceding chapter naturally falls under two heads, *e.g.*, (1) Method of treatment and (2) Results according to species of timber treated.

**1. METHOD OF TREATMENT.***(i) General discussion.*

The sleepers, with few exceptions, were treated by four distinct processes, *i.e.*, (a) Powellizing, (b) by the introduction of small quantities of high grade creosote, (c) with Chloride of Zinc followed by a coating of creosote oil and (d) by a full cell process using a mixture of Earth Oil and Creosote, introduced either by the Open Tank method or under Pressure. A few sleepers as recorded in section 7, part II, of this note, were treated with Creosote only.

*(ii) Powellizing.*

The results obtained by Powellizing have so far been eminently satisfactory, but more so in the drier regions than in the very wet localities. The reason why this process should give good results is not easy to explain, as the ingredients used are arsenic and a saccharine solution, both of which are soluble in water and therefore liable to be leached out of the wood by excessive moisture. This fact seems to be established to a certain extent by the results obtained, but not sufficiently so to prove the fact, as even in very wet localities the treated Pine have lasted over 9 years, whereas in an untreated state they do not last  $2\frac{1}{2}$  years when used as Railway sleepers. It is thought that by boiling the timber in a solution of arsenic and molasses and afterwards subjecting it to a drying process at high temperatures the fibre is sterilized and the solution taken up in combination with the inherent sap in the fibre, while the free sap is driven out by the heat.

*(iii) Treatment with small quantities of high grade creosote.*

The idea of testing the durability of sleepers treated with small quantities of high grade creosote was done purely with the object of attempting to reduce the cost of treatment. The results obtained cannot be said to be altogether unsatisfactory considering the low cost



of treatment, as in the case of the Pines the life has been trebled as compared with untreated timber, and about doubled in the case of the *Dipterocarps*. On the other hand the process cannot be advocated and is one more suitable for fencing posts than for railway sleepers.

(iv) *Treatment with Chloride of Zinc and small quantities of creosote to protect the salt.*

The third process consisted in treating the sleepers with a 2 per cent. solution of Chloride of Zinc and after allowing them to dry out, to dip them in a good grade of creosote, such as *Solignum* or *Green Oil*. This process like the second is one aiming at reducing the cost of treatment. Chloride of Zinc is about the only salt used for treating timber which has stood the test of time, though Fluoride Salts have of recent years come considerably to the front. The results are so far not encouraging, in fact strong indications are present to show that the sleepers which have been rather over seven years in the line are fast deteriorating. These results are corroborated by similar results obtained with this process in America. It was stated above that the process involved two separate treatments, by first treating the timber in the salt solution and then in oil and that the results were even then not satisfactory. A modification of this process has been introduced by Mr. Card, a Creosoting Engineer in the States, by which the salt and oil solutions are introduced simultaneously as an emulsion into the timber. The durability tests on sleepers treated in this way have given excellent results. The writer inspected a large plant working according to the Card process, owned by the Ohio-Baltimore Railway, which turned out over a million sleepers annually. It is probable that this process would do well in India, and at the same time keep down the cost of treatment as compared with the full cell Creosote process.

(v) *Treatment with a mixture of Earth Oil and Creosote according to the full cell process.*

The results of this experiment have been divided into two parts, namely, sleepers treated in open tanks and those treated under pressure. The sleepers have only been in the line from 5 to 6 years and therefore to compare their condition with those treated by other processes and which have been in the line for anything from 7 to 10 years is not possible. So far the sleepers treated in either open tanks or under pressure are doing uniformly well. They have been laid down under many varying conditions of climate, some being in the dry zone of the Central Provinces, others in Burma, many in Assam and others again in the Punjab. The process by which these sleepers were treated varies little from the full





Photo-Mech. Dept., Thomason College, Roorkee.

Section of a Powellized (Chir) *Pinus longifolia* B. G. sleeper, showing rail cut after being 9 years in the line, indicating the necessity of using bearing plates.

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cell creosoting method of preserving timber, which has not only stood the test of time but is one universally accepted all over the world where treated timber is used for Railway purposes, and is therefore one which we may look to as likely to give us satisfactory results.

No definite idea can as yet be formed as to the relative merits of treating in Open Tanks or Pressure Cylinders, as the period during which the experiments have been in progress is insufficient. On the other hand it can be stated definitely that the Open Tank treatment in any case is only of value if either the number of sleepers to be dealt with is small, or if the idea of treating sleepers is a temporary one or in default of a pressure cylinder. If the work is to be of a permanent nature and more than 25,000 to 50,000 sleepers are to be treated annually not only are better results obtained but it is more economical to put in a pressure plant.

## (2) RESULTS ACCORDING TO SPECIES TREATED.

### (i) *Treated 'Chir' sleepers.*

*Pinus longifolia.* Some years ago about 1,000 untreated 'Chir' sleepers were laid in the line as an experiment and they had all to be removed in 29 months, or roughly after  $2\frac{1}{2}$  years. The Powellized 'Chir' have lasted 9 years in very wet localities, and are still doing fairly well in the moderately moist and well in the dry localities. It can therefore now be stated definitely that Powellized 'Chir' sleepers will last four times as long as untreated 'Chir' sleepers, if not longer. The 'Chir' treated with a mixture of Earth Oil and Creosote have not been more than six to seven years under observation, but they too, from their present condition, have every indication of doing as well as the Powellized sleepers. The experiments are not yet complete as by far the greater number of the sleepers treated by different processes are still in the line, on the other hand we can fix the life of well treated 'Chir' sleepers fairly accurately. In dry localities they will probably last 12 to 13 years, in moderately dry 10 to 11 years and in wet localities 9 to 10 years. The above periods of duration are based on sleepers being laid in main lines, subjected to heavy traffic, and as the sleepers under experiment were neither selected before treatment nor laid to the best advantage, the above estimates may be taken as conservative. There can be no doubt whatsoever that when dealing with treated 'Chir' sleepers the best results can be obtained by laying them sap down and heart up and that the life of the sleepers can be considerably increased by using bearing plates. It is hardly necessary to state that the sleepers should be passed, and if possible bored and adzed, before treatment.

## (ii) Treated 'Kail' sleepers.

*Pinus excelsa*. Untreated 'Kail' sleepers were laid down as an experiment at the same time as the abovementioned untreated 'Chir' and also lasted less than  $2\frac{1}{2}$  years. The treated 'Kail,' both Powellized and impregnated with Earth Oil and Creosote, have given slightly better results than 'Chir,' though the difference is hardly commensurable with the difference in price of the two timbers. Though a treated 'Chir' sleeper may last about a year less than a treated 'Kail,' the former is probably a better financial investment than the latter. The remarks made against selecting and laying of 'Chir' apply with equal force to 'Kail' sleepers.

## (iii) Treated 'In' sleepers.

*Dipterocarpus tuberculatus*. Experiments were carried out in several localities with untreated 'In' sleepers and their life was found to be from 4 to 5 years. The Powellized 'In' sleepers were all laid in the line in one locality and that was a very wet one, on the East Bengal State Railway. They have been in the line  $9\frac{1}{2}$  years and are now fast failing and will probably last only 10 to 11 years. The 'In' sleepers treated with Earth Oil and Creosote and which have been in the Burma Railways for 6 to 7 years are doing well. As regards the durability of well treated 'In' sleepers it is only possible to give their life in wet and somewhat unfavourable localities, which is from 10 to 11 years, probably in drier localities it would be found to be from 12 to 13 years. The experiments with 'In' brought out one point very clearly which applies equally to all true *Dipterocarps* and that is that this class of sleeper almost invariably goes under the rail seat and round the spike hole. From examination of the sleepers it is thought that this deterioration is not so much due to rot as that the fibre being very straight laminates by cracking, in other words that deterioration is due to mechanical and not physical defects. There can be little doubt that the use of bearing plates should be insisted on with all classes of *Dipterocarps*, such as 'In,' 'Gurjan,' 'Kanyin' and 'Hollong' and that it is imperative to either bore the holes before treatment or if that is not possible to smear the spike holes with preservative at the time of boring and laying in the line.

## (iv) Treated 'Kanyin' sleepers.

*Dipterocarpus alatus*. Untreated 'Kanyin' sleepers last less than 4 years; if well treated they will last 9 years or possibly 10 in the drier localities. The Powellized 'Kanyin' laid in continuation of the abovementioned 'In' sleepers have fared not quite so well as the latter,





Photo-Mech. Dept., Thomason College, Roorkee.

Section of a Powellized "In" *Dipterocarpus tuberculatus* B. G. sleeper, showing deterioration of spike hole and cut under rail seat, after being 9 years in the line, indicating the necessity of using bearing plates.

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while those treated with Earth Oil and Creosote which have been 6 to 7 years in the line are in fair condition. The mode of deterioration of 'Kanyin' sleepers is similar to that of 'In,' and therefore the sleepers require to be laid with bearing plates, and the holes and adzed surfaces treated with the antiseptic.

(v) *Treated 'Hollong' sleepers.*

*Dipterocarpus pilosus.* 'Hollong' is the most likely sleeper wood in Assam, when considered for treatment, as it is plentiful, and can be procured near the line. A fair number of this species of sleepers were treated both under pressure and in open tanks, with Assam Earth (Residue) Oil and *Green Oil*. Their life in an untreated state is less than four years; the treated sleepers were laid in the line five and a half years ago, of which 75·4 per cent. are in Class 'A' and 18·3 per cent. in Class 'B,' or 94 per cent. in good order, the remaining 6 per cent. have been rejected. Though at present no report has been made of excessive rail cut and rot round the spikes, it will probably be found best to lay these sleepers with bearing plates and to treat the holes and adzed surface at the time of laying in the line.

(vi) *Treated 'Sain' sleepers.*

*Terminalia tomentosa.* The results obtained with untreated 'Sain' sleepers are extraordinarily variable, and their life may vary from anything between 3 and 8 years. They are often laid down in an untreated state, so that many records are available. If treated, and even not heavily so, they give by far the best results of any sleeper as yet experimented with. Take for instance the results of Powellized 'Sain,' laid in five different localities, varying from extremely hot and dry to extremes of hot and damp, and after 9 years in the line only 5 per cent. have been rejected. This result is the more striking in that nearly all those sleepers which make up the 5 per cent. were rejected for mechanical faults, due to the fact that the experimental sleepers were not passed before treatment and were cut from tops and butts. The life of well treated 'Sain' sleepers cannot yet be fixed, but it will without doubt be found to be well over 12 years. 'Sain' timber is heavy and hard, it holds the dog spikes extremely well and requires no bearing plate. As far as is at present known a well treated 'Sain' sleeper is about the best of any treated Indian timbers.

(vii) *Treated 'Hollock' sleepers.*

*Terminalia myriocarpa*. 'Hollock' sleepers were treated under pressure and laid in the Assam-Bengal Railway over five years ago. Like 'Sain' it is a hard timber, though not very easy to treat, on the other hand the sleepers are behaving remarkably well, 85 per cent. being still in the first class and 8 per cent. in the second and none in 'C' class. Those rejected amounting to 6 per cent. and were taken out of the line for mechanical defects. There appears to be every likelihood of 'Hollock' when treated, proving a very useful sleeper wood.

(viii) *Treated 'Sida' sleepers.*

*Lagerstræmia parviflora*. It is not known how long an untreated 'Sida' sleeper will last, but probably not more than 2 or 3 years. Those treated under pressure with Assam Earth Oil and *Green Oil* have been a little over 5 years in the line, and are doing fairly well. They are, however, not very satisfactory as this class of timber is very liable to split.

(ix) *Treated 'Sam' sleepers.*

*Artocarpus Chaplasha*. 'Sam' was treated in the same way as 'Hollock' and laid down at the same time. The experimental sleepers are doing well, 88 per cent. being still in the first class. They, like 'Hollock,' may prove to be a useful treated sleeper.

(x) *Treated 'Jutili' sleepers.*

*Altingia excelsa*. The 'Jutili' sleepers were treated in the same way as 'Hollock,' and laid down from four to five years ago in the Assam-Bengal Railway. Of these experimental sleepers 89 per cent. are still in Class 'A' and are doing well.

(xi) *Treated 'Gohari Sapa' sleepers.*

*Magnolia Sp.* A few 'Gohari Sapa' sleepers were treated in the same way as 'Hollock' of which 85 per cent. are still in Class 'A,' and are therefore doing well.

(xii) *Treated 'Ping' sleepers.*

*Cynometra polyandra*. 'Ping' wood is very liable to split, but is hard and well suited for sleepers, it is also plentiful. A few treated sleepers were laid down in continuation of the above, of which 78 per cent. are in Class 'A' after over five years. If this timber proves suitable it will help to solve the sleeper problem in Assam, as the timber is little used in that province.



## PART IV. Conclusions arrived at after ten years of experiments.

### 1. GENERAL.

Ten years have elapsed since the first lot of treated sleepers were laid down and dealt with according to the scheme for experiments prepared by the Forest Research Institute, Dehra Dun, so that it is now possible to summarise some of the results obtained. When the experiments were first started Railway Engineers looked on them with good humoured tolerance, and some of them were perhaps somewhat cynical. To-day many accept the fact that to treat certain Indian timbers will give satisfactory results, and this, if nothing else, is a sufficient justification for having spent much money, time and thought on the experiments. If further justification is necessary it may be stated that one railway is about to erect a pressure plant, while at least three others are seriously contemplating doing so. The writer has no doubt in his mind that within a few years the treatment of sleepers will be a well established industry in India, as it is at present in every other civilized country.

### 2. CHOICE OF METHOD OF TREATMENT.

From results obtained to date the choice of treatment lies between (i) the Full Cell process, using either Creosote only or Earth Oil and Creosote and (ii) Powellizing, the choice between these two processes being a question of cost of treatment. If Creosoting is selected, it should be by the Full Cell process, though cost of treatment may enforce the use of a certain percentage of Earth Oil, which until further experiments have been carried out should not exceed 50 per cent., *i.e.*, equal parts of Creosote and Earth Oil. In the case of Powellizing there appears no reason to adhere to the old method of introducing the antiseptic in open tanks, as by doing so in pressure cylinders will result in deeper penetration.

The other two processes tried, one by which the timber was treated with small quantities of a high grade Creosote and the other of treating first with Chloride of Zinc and then covering it with small quantities of Creosote, are not advocated.

Further experiments on a fairly large scale are, however, strongly advocated with sleepers treated (i) according to the Open Cell or Rüping process, and (ii) by the Card process, which involves introducing an

emulsion of Creosote and Chloride of Zinc into the timber, and (iii) of treating the sleepers by the Card process, with Fluoride salts and Creosote.

### 3. INTRODUCTION OF THE ANTISEPTIC INTO THE TIMBER.

An antiseptic solution can either be introduced into the timber in Open Tanks or in Pressure Cylinders. If the work is of a permanent nature and more than 25,000 and at the outside 50,000 sleepers are to be treated annually, a pressure plant must be installed. Treatment of sleepers in Open Tanks can only be a temporary measure; it is more suited for treating posts and small quantities of building material than for sleepers.

### 4. SPECIES OF TIMBER SUITABLE FOR TREATMENT.

As far as experiments have gone in India, the *Terminalias* have given the best results. So far only *Terminalia tomentosa* (Sain) and *Terminalia myriocarpa* (Hollock) have been tested, but *Terminalia paniculata* (Kindal) of which large supplies are available from the West Coast, will probably give excellent results, if properly seasoned and then well treated. *Terminalia Manii* and *Terminalia procera*, both from the Andamans, should also be satisfactory.

*Dipterocarps* probably come next in importance, of which *Dipterocarpus tuberculatus* (In), *Dipterocarpus alatus* (Kanyin) and *Dipterocarpus pilosus* (Hollong) have all given good results. *Dipterocarpus turbinatus* (Gurjan) and *Dipterocarpus Griffithii* (Kanyinbyan) should be also added to the list.

Of the Pines, *Pinus excelsa* (Kail) and *Pinus longifolia* (Chir) have been tested with satisfactory results, of which the latter, due to its greater abundance and relatively lower price is the most likely to answer the purpose.

The firs, namely *Abies Pindrow* (Silver Fir) and *Picea Morinda* (Spruce) have not been tested on a sufficiently large scale to allow of their being definitely classed as sleeper woods after treatment. On the other hand there are indications to show that they may answer the purpose, and as they are plentiful and cheap in the Punjab they are likely to be given a large scale trial.

A fairly large number of Assam woods other than 'Hollong' and 'Hollock' are under experiment, of which several show great promise, but as the experiments have only been in progress a little over 5 years a definite statement cannot as yet be made as to their suitability for treatment as sleepers.

## 5. MISCELLANEOUS POINTS BROUGHT OUT BY THE EXPERIMENTS.

The question of carefully passing sleepers before treatment was very prominently brought out by these experiments. With few exceptions this was not done, with the result that a few sleepers of each batch had to be rejected for mechanical defects soon after they were laid down. The great importance of laying treated Pine sleepers heart up and sap down was also a noticeable feature of the results, while the necessity of adzing and boring sleepers before treatment, whenever possible, was clearly demonstrated in the case of the *Dipterocarp* sleepers, which only failed under the rail seat while the rest of the timber was in a sound condition. And lastly, too much care cannot be taken in selecting the grade of creosote to be used: analyses should be made of every bulk sample received for treating sleepers.

## APPEN

Statement showing the average annual number and class of

Serial No.	Name of Railway by whom purchased.	Number of years on which the average is based.	( <i>Tectona grandis</i> ). Teak.	( <i>Shorea robusta</i> ). Sal.	( <i>Cedrus deodara</i> ). Deodar.	( <i>Xylia dolabriformis</i> ). Pyinkado.
					(i) Broad Gauge	
1	North Western Railway	1	...	...	324053 16419 (special sizes).	...
2	East Indian Railway Co., Ltd.	10	...	138326 (C. P. Sal) 2156 (Nepal).	34139	...
3	H. E. H. the Nizam's Guaranteed State Railway Co., Ltd.	12	506 (Indian), 2141 (Java).	4193	...	834
4	Madras and Southern Mah-ratta Railway Co., Ltd.	10	...	20509	1494	4453
5	Oudh and Rohilkhand Rail-way.	10	...	16803 (Nepal Sal) 8447 (Hill Sal) 19832 (C. P. Sal) 2625 (Cross-ties) 1550 (Bridge sleepers).	34762 and 466 (Cross-ties).	4111
6	Bombay, Baroda and Central India Railway Co., Ltd.	10	3142 (Half round).	...	..	...
7	Bengal Nagpur Railway Co., Ltd.	8	...	94051 and 8820 (Various sizes).	...	1060 (Various sizes).
8	Great Indian Peninsula Rail-way Co., Ltd.	10	1125	11306	6500	695
9	Eastern Bengal Railway Co., Ltd.	12	..	85810 (Nepal Sal).	4167	...
	Total	...	7214	415915	422029	11153



## DIX I.

*Railway sleepers purchased by Indian Railways.*

( <i>Terminalia tomentosa</i> ). Sain.	( <i>Pinus longifolia</i> ). Chir.	( <i>Picea Morinda and Abies Pindrow</i> ) Spruce and Silver Fir.	( <i>Eucalyptus marginata</i> ). Jarrah.	Other species.	TOTAL.
Sleepers.					
5000	141719	95732	...	.. ...	582952
6066	2500	...	15258	2675 (Red wood), 11827 (Creosoted Douglas), 700 (Yang), 12155 (mixed hardwoods, Burma).	225802
...	...	...	...	18809 (Iron Bark), 864 (Indian hardwoods).	27347
1500 (Burma).	...	...	26105	5455 (Maiyang), 1199 (Douglas Creosoted), 1000 (Burma hardwoods), 7062 (West Coast hardwoods).	68777
41	3090	...	10000	1200 (N. S. W. Hardwoods), 3380 (Burma softwoods).	105857
...	...	...	...	59866 (Species not known, but chiefly Indian timbers).	63308
20227 (Various sizes).	...	...	...	1250 (Apitong), 6896 (Kian), 675 (Hardwoods), 165 (Kamzar wood, crossing sleepers), 340 (Kapur crossing sleepers), 7500 (Dhaura), 312 (Dhaura crossing sleepers), 625 (Eng).	142069
...	...	...	73860	2889 (Maiyang), 7955 (Malabar hardwood), 2681 (Redwood), 2769 (Japanese Oak), 2414 (Eng. wood), 58 (Californian), 1180 (Burmese), 10 (Taukkyan).	113742
...	...	...	15498	28 (Red Cedar wood), 854 (American Red wood), 4833 (Douglas Fir wood), 3333 (Burma wood).	116460
32084	147309	95732	140721	173257	1446314

## APPEN

Statement showing the average annual number and class of

Serial No.	Name of Railway by whom purchased.	Number of years on which the average is based.	( <i>Tectona grandis</i> ). Teak.	( <i>Shorea robusta</i> ). Sal.	( <i>Cedrus deodara</i> ). Deodar.	( <i>Xylia dolabri-formis</i> ). Pyinkado.
(ii) Metre Gauge						
1	Dibru-Sadiya Railway Co., Ltd.	11	...	1584	...	...
2	North Western Railway	1	...	...	66484	...
3	Bengal and North Western Railway Co., Ltd.	11	...	224423	410	398
4	Burma Railway Co., Ltd.	9½	...	...	...	282224
5	H. E. H. the Nizam's Guaranteed State Railway Co., Ltd.	12	327	...	...	...
6	Jodhpur-Bikaner Railway Co., Ltd.	10	...	13723	90074	...
7	Rohilkund and Kumaon Railway Co., Ltd.	10	...	70692	...	...
8	Madras and Southern Mahratta Railway Co., Ltd.	10	64848	28821	...	...
9	Oudh and Rohilkhand Railway.	10	...	9188 and 68 (Crossing sleepers). 64 (Bridge sleepers).	...	...
10	Bombay, Baroda and Central India Railway Co., Ltd.	10	6246 (Half round).	169162	67634	...
11	Assam Bengal Railway Co., Ltd.	11	...	46841 (C. P. Sal), 8358 (Assam Sal), 2273 (Himalayan Sal).	...	12719
12	Eastern Bengal Railway Co., Ltd.	12	...	112444 (Indian Sal), 1314 (Nepal Sal).	8333	...
	Total	...	71421	688955	232935	296341

DIX I—*contd.**Railway sleepers purchased by Indian Railways—contd.*

( <i>Terminalia tomentosa</i> ). Sain.	( <i>Pinus longifolia</i> ). Chir.	( <i>Picea Morinda and A.ies Pindrowe</i> ). Spruce and Silver Fir.	( <i>Eucalyptus margi- nata</i> ). Jarrah.	Other species.	TOTAL.
Sleepers.					
...	...	...	...	42916 (Uriam, <i>Bischofia javanica</i> ), 4470 (Nahor, <i>Mesua ferrea</i> ).	48970
..	839	1845	...	.....	69168
...	...	...	37596	9040 (Douglas), 692 (Creopine)	273549
41148	...	...	...	27506 (Thitya and Ingyin, <i>Shorea obtusa</i> and <i>Pentacme suavis</i> ).	349878
...	...	...	...	394 (Ironwood), 174 (Indian Hardwoods)	895
...	...	...	...	4001 (Malyang)	107798
39	533	...	...	.....	71314
...	...	...	5063	5000 (Australian Hardwoods), 2677 (Douglas creosoted).	106499
...	...	...	...	.....	9220
...	...	...	5565	14297 (Oregon Pine), 5613 (Redwood), 790 (Species not known).	269307
45	...	...	27328	359 (Slant kyan), 454 (Japanese Oak), 9111 (American Redwood), 10009 (Douglas Fir), 10808 (Ajhar L. <i>Flos-Reginae</i> ), 100 (New South Wales Bound Buck), 168 (Barjam Khorjam), 2 (Nigerian sleepers), 1612 (Nahor, <i>Mesua ferrea</i> ).	130987
...	...	...	8644	42 (Red Cedar), 2218 (American Red wood), 1074 (Apitong wood).	134269
40222	1422	1845	84386	154327	1571864

## APPEN

Statement showing the average annual number and class of

Serial No.	Name of Railway by whom purchased.	Number of years on which the average is based.	( <i>Tectona grandis</i> ). Teak.	( <i>Shorea robusta</i> ). Sal.	( <i>Ceirus decodra</i> ). Deodar.	( <i>Xylia dolabriformis</i> ). Pyinkado.
					(iii) Narrow Gauge	
	North Western Railway	1	...	54252	43495	...
	Darjeeling Himalayan Railway Co., Ltd.	10	...	5181	...	...
	Bombay, Baroda and Central India Railway Co., Ltd.	10	4665 (Half round).	...	...	...
	Bengal Nagpur Railway Co., Ltd.	8	...	104630 and 452 (Various sizes).	...	...
	Total	...	4665	164515	43495	...

§ The General Manager estimated that in a few years their  
 ¶ Average requirements estimated at 200,000 B. G.,

## Grand Totals for

Name of Railway.	D. S. Ry. Co., Ltd.	N. W. Ry. Co.	B. N. W. Ry. Co., Ltd.	E. I. Ry. Co., Ltd.	Burma Ry. Co., Ltd.	H. E. H. N. G. S. R. Co.	R. K. Ry. Co., Ltd.	J. B. Ry. Co., Ltd.
Number of B. G. sleepers.	...	582,952	...	225,892	...	27,347	...	...
Number of M. G. sleepers.	48,970	69,168	273,549	...	349,878	895	71,314	107,798
Number of N. G. sleepers.	...	97,747	...	...	...	...	...	...



## DIX I—concl'd.

*Railway sleepers purchased by Indian Railways—concl'd.*

( <i>Terminalia tomentosa</i> ). Sain.	( <i>Pinus longifolia</i> ). Chir.	( <i>Picea Morinda</i> and <i>Abies Pindrow</i> ). Spruce and Silver Fir	( <i>Eucalyptus marginata</i> ). Jarrah.	Other species.	TOTAL.
Sleepers.					97747
...	...	...	...	....	
58	...	...	...	335 (Oak and Chestnut) . . .	56745
...	...	...	...	7339 (Species not known) . . .	120017
...	...	...	...	31 ( <i>Ainee</i> , <i>Artocarpus hirsuta</i> ) . . .	105113
58	...	...	...	7725	220438

requirements for renewals will amount to from 15,000 to 18,000 sleepers annually.  
2,50,000 M. G., 15,000 N. G.

*all Railways.*

O. R. Ry. Co.	B., B. & C. I. Ry. Co., Ld.	B. N. Ry. Co., Ld.	A. B. Ry. Co., Ld.	G. I. P. Ry. Co., Ld.	E. B. Ry. Co., Ld.	D. H. Ry. Co., Ld.	M. & S. M. Ry. Co., Ld.	S. I. Ry. Co., Ld.	TOTAL.
105,857	63,308	142,069	...	113,742	116,460	...	68,777	...	1,446,314
9,320	269,307	...	130,987	...	134,269	...	106,400	...	1,571,864
...	12,004	95,113	...	...	...	5,574	...	...	220,438

Grand total of all kinds of sleepers purchased annually by Indian Railways, 3,238,616

## APPENDIX NO. II.

## Record of Experimental Powellised Sleepers laid in open lines.

Serial No.	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	C	R	Total
1	<i>Pinus longifolia</i> (Chitr).	197 B. G. . . .	North Western Railway. Between Ranipur Riyasat and Gambat. Mile 261-14 and 261-17.	5th December 1911.	6th January 1921 .	66	111	15	5	197
						Sleepers in fair to good condition. One badly and two slightly attacked by white ants. Spikes holding well. Rail cut moderate, bearing plates necessary.				
2	Ditto	52 B. G. with bearing plates.	North Western Railway. Sibi-Quetta Section. Mile 206-16 to 206-17.	1st March 1912 .	3rd January 1921 .	26	13	11	2	52
						In fair condition.				
3	Ditto	49 B. G. without bearing plates.	Ditto	Ditto	Ditto	19	21	1	8	49
						Not in such good condition, the bearing plates have helped the sleepers recorded in No. 2.				
4	Ditto	152 B. G. . . .	Oudh and Rohilkhand Railway. Cawnpore-Lucknow Branch. Mile 1-24 to 1-24.	December 1911 .	4th February 1921.	0	61	87	4	152
						Generally speaking the sleepers will have to be removed in two years. Spikes loose, probably due to use of screw spikes. Those sleepers laid heart up noticeably better. No white ant attack.				
5	Ditto	152 B. G. . . .	Oudh and Rohilkhand Railway. Hardwar-Liaksar Section. Mile 3-17 to 4-1.	15th January 1912 .	30th November 1920	54	89	2	7	152
						Condition fair to good, slightly more split than when last inspected, spike holding well, no white ant attack. None rejected since last inspection.				

	210 B. G.	10th April 1912	15th March 1921	
6	Ditto	Eastern Bengal State Railway. Down line north of Ranaghat. Mile 46-4 to 46-10.		These sleepers were inspected in February 1920, when 194 were still in the line. When inspected in March 1921 they were all rejected. Rail cut bad, no bearing plates. Life 9 years. Experiment closed.
7	<i>Pinus excelsa</i> (Kall)	North Western Railway, Bet-ween Rampur-Birsaat and Gambhat. Mile 261-12 to 261-14.	5th December 1911	6th January 1921
8	Ditto	North Western Railway, Sibbi-Quetta Section. Mile 206-15 to 206-16.	1st to 10th March 1912.	3rd January 1921
9	Ditto	Ditto	Ditto	Ditto
10	Ditto	Onah and Rohilkhand Railway, Cawnpore-Lucknow Branch. Mile 1-4 $\frac{1}{4}$ to 1-6.	December 1911	4th February 1921
11	Ditto	Onah and Rohilkhand Railway, Hardwar-Lhaksar Mile 4-1 to 4-2.	7th February 1912.	30th November 1920.
12	<i>Pinus excelsa</i> and <i>Pinus longifolia</i> B. G. mixed.	Eastern Bengal State Railway, Down line north of Ranaghat. Mile 46-4 to 46-10.	10th April 1912	15th March 1921

## APPENDIX NO. II—contd.

Serial No.	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	C	R	Total
13	<i>Dipterocarpus tuberculatus</i> (In).	434 B. G. . . . .	Eastern Bengal State Railway. Down line 4,000 feet from the centre of Nahati platform. Mile 22-11 to 22-20.	6th October 1911 .	15th March 1921 .	34	360	40		434
						No bearing plates. Due to cut and rot at rail seat, which is now almost universal, these sleepers will have to be replaced in the near future. Ends and middle of sleepers sound and very little cracked. No white ant attack. Were this species of timber to be laid with bearing plates, the life of the sleepers could be considerably increased.				
14	<i>Dipterocarpus alatus</i> (Kanyin).	121 B. G. . . . .	Ditto	Ditto	Ditto	18	64	39		121
						No bearing plates. As above, trouble at rail seat. The sleepers are more split than the above. The use of bearing plates would without doubt increase the life of these sleepers.				
15	<i>Terminalia tomentosa</i> (Sain).	79 B. G. with and 78 B. G. without bearing plates.	North Western Railway. Between Ranpur-Rivasut and Gambat. Mile 261-9 to 261-12	21st July 1911 .	6th January 1921 .	88	54	7	8	157
						Sleepers in good condition, no sign of white ant attack. Spikes holding well. Bearing plates not required with this timber. No rejections since last inspection.				
16	Ditto	58 B. G. with and 58 B. G. without bearing plates.	North Western Railway. Sibhi-Quetta Section. Mile 206-17 to 206-18.	1st to 15th August 1911.	3rd January 1921 .	87	16	5	8	116
						In good condition. Rail cut slight, no white ant attack, spikes holding well. No difference between sleepers laid with and without bearing plates.				



17	Ditto	187 B. G. . . . .	Oudh and Rohilkhand Railway. Cawnpore-Ducknow Branch. Mile 1-6 to 1-8½.	September 1911 .	4th February 1921.	93   74   16   4   187   3 Sleepers still in very good condition. Dog spikes holding well. Three rejections since last inspection. Not 5 per cent. of dog spikes have been redriven. No white ant attack.
18	Ditto	131 B. G. . . . .	Oudh and Rohilkhand Railway. Hardwar-Dubaut Section. Mile 3-10 to 3-17.	1st September 1911	30th November 1920	93   34   2   2   131   7 Sleepers in good condition. Spike holding well, rail cut insignificant. Much in the same condition as when inspected two years ago.
19	Ditto	121 B. G. . . . .	Eastern Bengal State Railway. Down line north of Ranaghat. Mile 4-6-10 to 4-6-11.	22nd June 1913 .	15th March 1921 .	36   125   39   22   222   4 Cracking noticeable throughout though it has not led to decay. Original defects noticeable due to sleepers not having been passed in first instance. In about 20 cases signs of rot on surface. Rail seat good. Screw spike loose in some cases. No white ant attack.
		101 B. G. . . . .	Down line near Chelaram's brick-field. Mile 4-6-11 to 4-6-12.	Ditto	Ditto	

Percentages according to species ; condition after the sleepers have been 9 to 10 years in line.

Serial No.	Species.	Period under observation to date of last inspection.		A per cent.	B per cent.	C per cent.	R per cent.	Total number of sleeper on which percentages are based.
		Years.	Months.					
1	<i>Pinus longifolia</i> (Chir).	9	0	20.3	36.3	14.2	29.2	812
2	<i>Pinus excelsa</i> (Kail).	9	1	44.4	37.8	11.8	6.0	431
	<i>Dipterocarpus tuberculatus</i> (In).	9	5	—	8.0	83	9.0	434
4	<i>Dipterocarpus alatus</i> (Kanyin).	9	5	—	15.0	53.0	32.0	121
5	<i>Terminalia tomentosa</i> (Sain).	9	1	49.0	37.1	8.4	5.5	813

NOTE.—For explanation of the above figures see pages 9-11 in body of report.

NOTE.—A—Good in all respects.  
B—Slightly split, decayed or attacked by white ants.  
C—Badly split, decayed or attacked by white ants.  
R—Rejected.  
O—Original defects.

## APPENDIX NO. III.

Record of Experimental Sleepers treated in Open Tanks with *Avenarius Carbolineum Oil*, laid in open lines.

Serial No.	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	C	R	Total O
1	<i>Pinus longifolia</i> (Chr).	326 B. G. . . . .	North Western Railway, Saharanpur District. Between Begunabad and Muradnagar. Mile 12.5 to 12-9½.	25th July 1913 .	2nd February 1921	84	130	33	79	326
						Sleepers rapidly deteriorating, dry rot set in but no sign of white ant attack. Splitting considerable. Sleepers containing sap wood showing cup shake. Only about 4 lbs. of oil introduced per B. G. sleeper.				
2	<i>Pinus excelsa</i> (Kail).	400 B. G. . . . .	As above. Mile 12-4½ to 20 .	11th July 1913 .	Ditto	352	44	3	1	400
						Sleepers still doing well. Spike holding well and underside of sleepers invariably good. With the exception of one sleeper attacked on surface, there is no sign of white ant attack. Absorption of oil as above.				
3	<i>Dipterocarpus tuberculatus</i> (In).	134 M. G. . . . .	Burna. Railways. Toungoo District, at Pyimmana. Mile 225-7 to 225-8½.	21st December 1912	20th August 1920 .	80	8	20	26	134
						Fair condition, will still last a season or two, except those in class C. A few attacked by white ants. Some dry rot set in, especially round spike holes.				
4	Ditto	133 M. G. . . . .	Burna. Railways. Mandalay District, between Myitng and Paundang. Mile 378-12½ to 378-14.	8th December 1912	August 1919 .	133	1			133
						Some rather split, but on the whole the condition of these sleepers is good.				
5	Ditto	133 M. G. . . . .	Burna. Railways. Mandalay District, outside Naymyo. Mile 421-12 to 421-15½.	25th January 1913	24th August 1920 .	126		7		133
						Rejections due to white ant attack. Remainder fair and may last 2 or 3 seasons more.				
6.	<i>Dipterocarpus dalus</i> (Kanyin).	134 M. G. . . . .	Burna. Railways. Toungoo District, at Pyimmana. Mile 225-10 to 225-12½.	21st December 1912	Ditto	94		40		134
						In poor condition. Cause of rejection white ants and dry rot round rails and spike holes.				

	Ditto	133 M. G. . . .	Burma Railways, Mandalay District, between Myitnge and Tacundaling. Mile 378-10 to 378-11½.	8th December 1912	Ditto	109   24   133   Nearly all the sleepers are badly split. Spikes not holding very well.
8	Ditto	133 M. G. . . .	Burma Railways, Mandalay District, outside Maymyo. Mile 421-15½ to 421-17½.	25th January 1913.	Ditto	93   40   133   Reason for rejection decay, some sleepers being more shiels. Half those remaining in the line are expected to go in a year and all will be removed in the next 3 years.
9	<i>Terminalia tomentosa</i> (Sain).	100 M. G. . . .	Rohilkund and Kumaon Railway. Between Aliganj and Kashipur. Mile 30-7 to 30-8.	29th June 1913 .	29th December 1920	63   13     24   100   The defects are due to cracking
10	Ditto	100 M. G. . . .	Rohilkund and Kumaon Railway. Between Sitapur and Jharkpur. Mile 55-13 to 55-14.	8th August 1913 .	21st February 1921	65   15   7   13   100   Sleepers doing fairly well.
11	Ditto	195 M. G. . . .	Rohilkund and Kumaon Railway. Between Bhojepura Junction and Izatnagar. Mile 193 to 193-4.	4th August 1913 .	22nd March 1921 .	195         195   Sleepers in good condition and gauge is keeping well. Some sign of surface cracking, which is not preventing the spikes holding well.

Percentage according to species; Condition after the sleepers have been from 7 to 8 years in the line.

Serial No.	Species.	Period under observation to date of inspection.		A per cent.	B per cent.	C per cent.	R per cent.	Total number of sleepers on which percentages are based.
		Years.	Months.					
1	<i>Pinus longifolia</i> (Chir)	7	6	25.77	39.88	10.12	24.23	326
2	<i>Pinus excelsa</i> (Kail)	7	6	88.0	11.0	.75	.25	400
3	<i>Dipterocarpus tuberculatus</i> (In)	7	7		91.75		8.25	400
4	<i>Dipterocarpus alatus</i> (Kanyin)	7	7		74.0		26	400
5	<i>Terminalia tomentosa</i> (Sain)	7	7		88.9	1.87	9.3	395

NOTE.—A—Good in all respects.  
B—Slightly split, decayed or attacked by white ants.  
C—Badly split, decayed or attacked by white ants, early rejection expected.  
R—Rejected.  
O—Original defect.

## APPENDIX NO. IV.

*Record of Experimental Sleepers treated in Open Tanks with Chloride of Zinc and Green Oil or Avenarius Carbolineum, laid in open lines.*

Serial No.	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	R	Total	O
1	<i>Pinus longifolia</i> (Chr).	100 B. G. . . .	North Western Railway, Between Moradnagar and Begunabad. Mile 1-21 to 12-1.	3rd August 1913 .	2nd February 1921	24	44	19	13	100
						A poor lot of sleepers when originally treated. Deterioration rapid. Much split, which may be partly due to overtreating in treatment. Dry rot common. Spike holding well where sleepers are sound.				
2	<i>Pinus excelsa</i> (Kail)	98 B. G. . . .	North Western Railway, Between Moradnagar and Begunabad. Mile 12-24 to 13-2.	4th August 1913 .	Ditto	71	15	9	3	98
						The C class chiefly suffering from dry rot under bearing plates. Spike holding well, rail cut insignificant. No white ant attack.				
3	<i>Dipterocarpus tuberculatus</i> (In).	210 M. G. . . .	Burma. Railways. Near Pwinmana. Mile 224-13 to 224-15½.	23rd July 1913 .	24th August 1920 .	79	83	57	219	
						Fast deteriorating, rot under rail and round spike hole. Some sleepers developed longitudinal cracks.				
4	Ditto	218 M. G. . . .	Burma. Railways, Mandalay District, north of Myingyan. Mile 352-16 to 352-18.	25th October 1913	August 1919 .	212	2	4	218	
						When last inspected the sleepers were in fair condition though sun cracks were noticeable and a few badly cracked.				
5	<i>Dipterocarpus alatus</i> (Kanyin).	218 M. G. . . .	Burma. Railways. Near Pwinmana. Mile 224-9 to 224-12.	19th July 1913 .	24th August 1920 .	36	25	157	218	
						Fast deteriorating. 25 now unserviceable. Cause of rejection rot under rail seat and round spike hole.				



0	Ditto	198 M. G.	Burma Railways, Mandalay District. Mile 378-15 to 378-17.	5th October 1913.	August 1910.	93   94   11   198
						The exact number in classes A, B and C is not known. A, B and C is not known. Many have been rejected. Many are split and a few show signs of rot. A poor lot on the whole.
7	<i>Termitia tomentosa</i> (Sain).	202 B. G.	Great Indian Peninsula Railway, Betul District, Harsi-Badnur Section. Mile 516-110 $\frac{1}{2}$ to 516-13 $\frac{1}{2}$ .	October 1913	31st May 1921	16   276   292
						The sleepers have proved thoroughly unsatisfactory. The cause of rejection being chiefly white ant attack and in some cases dry rot.
8	<i>Dipterocarpus alatus</i> (Kanyin).	22 M. G.	Burma Railways. Near Pynmana. Mile 224-9.	July 1913.	24th August 1920.	
						These sleepers were treated with Atlas solution and Green Oil. It has been rejected up to date, still in the line of which 5 are now unserviceable. The rest will last another season.

Percentage according to species; Condition after the sleepers have been in the line 7 to 8 years.

Serial No.	Species.	Period under observation to date of inspection.		A per cent.	B per cent.	C per cent.	R per cent.	Total number of sleepers on which the percentage is based.
		Years.	Months.					
1	<i>Pinus longifolia</i> (Chir).	7	6	24	44	19	13	100
2	<i>Pinus excelsa</i> (Kail)	7	6	72.4	15.3	9.2	3.1	98
3	<i>Dipterocarpus tuberculatus</i> (In)	7	1	66.6		19.4	14	437
4	<i>Dipterocarpus alatus</i> (Kanyin)	7	1	31.2		28.4	40.4	416
5	<i>Termitia tomentosa</i> (Sain)	7	6	—	—	5.5	94.5	292

NOTE.—A—Good in all respects.  
 B—Slightly split, decayed or attacked by white ants.  
 C—Badly split, decayed or attacked by white ants, early rejection expected.  
 R—Rejected.  
 O—Original defects.

## APPENDIX NO. V.

Record of Experimental Sleepers treated in Open Tanks with Solignum or Green Oil and Burma Oil or Liquid Fuel and laid in open lines.

Serial No.	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	C	R	Total
1	<i>Pinus longistolia</i> (Ch Ir).	B. G. . . .	North Western Railway. Ferozepur District. Between Sohawal and Amruka. Mile 149-16 to 149-17.	November 1914	30th May 1921	21	49	13		83
						Sleepers generally in good condition. Rail cut slight under bearing plates. No rejection since last inspection, though 2 sleepers were rejected at this inspection. Signs of white ants attack on 2 sleepers.				
2	Ditto	Ditto	North Western Railway. Ferozepur District. Between Fazilka and Ladhuka. Mile 123-15 to 123-17.	Ditto	Ditto	18	55	10		83
						As above.				
3	Ditto	Ditto	North Western Railway. Ferozepur District. Between Gurbarsahal and Jhok Tal Singh. Mile 95-6 to 95-7.	Ditto	Ditto	14	57	12		83
						As above.				
4	<i>Pinus excelsa</i> (Kail)	33 B. G. . . .	North Western Railway. Ferozepur District. Between Sohawal and Amruka. Mile 149-16 to 149-17.	Ditto	Ditto	13	16	4		33
						As above.				
5	Ditto	Ditto	North Western Railway. Ferozepur District. Between Fazilka and Ladhuka. Mile 123-15 to 123-17.	Ditto	Ditto	6	25	2		33
						As above.				
6	Ditto	34 B. G. . . .	North Western Railway. Ferozepur District. Between Gurbarsahal and Jhok Tal Singh. Mile 95-6 to 95-7.	Ditto	Ditto	16	18			34
						As above.				
7	<i>Dipterocarpus tibericulatus</i> (In).	30 M. G. Treated with liquid fuel oil only.	Burma Railways. Near Pyinmana. Mile 225-14 to 225-15	22nd June 1914	24th August 1920	27			3	30
						All in good condition.				
8	Ditto	470 M. G. . . .	Burma Railways. Near Pyinmana. Mile 225-19 to 226-4.	Ditto	Ditto	437		5	28	470
						Condition generally good. A few attacked by white ants. They will last two seasons or more.				

9	<i>Dipterocarpus alatus</i> (Kanyin).	500 M. G. . . .	Burma Railways. Near Pyin- mana. Mile 225-15½ to 225-19½	Ditto	Ditto	397   60   43   500   Condition fair. Some dry rot under rail and round spike. A few attacked by white ants.
10	<i>Terminatia tomentosa</i> (Sam).	460 B. G. and 65 B. G. sleepers laid after.	Great Indian Peninsula Railway. Harsi-Nagpur Section. Near entrance to Parassia Station. Mile 596-73 to 596-97.	9th June 1915	2nd May 1921	510   7   6   2   The sleepers are proving fairly satisfactory to date.
11	<i>Cedrus</i> <i>Deodara</i> (Deodar).	16 B. G. . . .	North Western Railway. Feroze- pur District. Between Sohau- wala and Amruka. Mile 149-16 and 149-17.	November 1914	30th May 1921	13   2   1   16   Sleepers generally in good order. Rail cut under plate small. None rejected since being laid in line.
12	Ditto	18 B. G. . . .	North Western Railway. Feroze- pur District. Between Gurni- barsahal and Jhok Tal Singh. Mile 95-6 to 95-7.	Ditto	Ditto	9   8   1   18   As above.
13	Ditto	16 B. G. . . .	North Western Railway. Feroze- pur District. Between Fazilka and Ladhuka. Mile 123-15 to 123-17.	Ditto	Ditto	8   5   3   16   As above.
14	<i>Altingia</i> <i>exelsa</i> (Jutill).	10 M. G. . . .	Assam Bengal Railway. District No. III. Near Moriani. Mile 479-3 to 479-4½.	November 1915	5th March 1921	10       10   A good lot of sleepers. No rail cut or loose spikes Surface cracking negligible.
15	<i>Terminatia myrio- carpa</i> (Hollock).	8 M. G. . . .	Ditto	Ditto	Ditto	8       8   All in good condition.
16	<i>Mangolia</i> <i>spp.</i> probably <i>Pentlana</i> (Gahori sapa).	11 M. G. . . .	Ditto	Ditto	Ditto	10     1   11   Sleepers in good condition except one.
17	<i>Dillenia</i> <i>indica</i> (Otinga).	31 M. G. . . .	Ditto	Ditto	Ditto	9   15   4   3   31   Surface splitting considerable, and the sleepers will probably deteriorate on this account.
18	<i>Dipterocarpus pilosus</i> (Hollong).	42 M. G. . . .	Ditto	Ditto	Ditto	38   2     2   42   A good lot of sleepers. Spikes holding well and rail cut insignificant.
19	<i>Cynometra polyantha</i> (Ping).	8 M. G. . . .	Ditto	Ditto	Ditto	7   1     8   In good condition.

Percentage according to species ; Condition after the sleepers have been in the line  $5\frac{1}{2}$  to  $6\frac{1}{2}$  years.

Serial No.	Species.	Period under observation to date of inspection.		A per cent.	B per cent.	C per cent.	R per cent.	Total number of sleepers on which percentages are based.
		Years.	Months.					
1	<i>Pinus longifolia</i> (Chir)	6	6	21.3	64.7	14.0	—	249
2	<i>Pinus excelsa</i> (Kail)	6	6	35	59	6	—	100
3	<i>Dipterocarpus tuberculatus</i> (In)	6	2	92.8	—	1	6.2	500
4	<i>Dipterocarpus alatus</i> (Kanyim)	6	2	79.4	—	12	8.6	500
5	<i>Terminalia tomentosa</i> (Sain)	5	11	97.1	1.4	1.1	0.5	525
6	<i>Cedrus Deodara</i> (Deodar)	6	6	60	30	10	—	50
7	<i>Terminalia myriocarpa</i> (Hollock)	5	4	100	—	—	—	8
8	<i>Magnolia</i> sp. (Gahori Sapa)	5	4	90.9	—	—	9.1	11
9	<i>Dillenia indica</i> (Otinga)	5	4	29	48.4	12.9	9.7	31
10	<i>Altingia excelsa</i> (Jutill)	5	4	100	—	—	—	10
11	<i>Dipterocarpus pilosus</i> (Hollong)	5	4	90.5	4.8	—	4.7	42
12	<i>Cynometra polyandra</i> (Ping)	5	4	87.5	12.5	—	—	8

NOTE.—A—Good in all respects.  
 B—Slightly split, decayed or attacked by white ants.  
 C—Badly split, decayed or attacked by white ants.  
 R—Rejected.  
 O—Original defects.



## APPENDIX NO. VI.

*Record of experimental Sleepers treated under pressure with mixed Green Oil and Assam Earth Oil and laid in open lines.*

[Serial No.]	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	C	R	Total
1	<i>Lagerstrœmia parviflora</i> (Stœb.).	151 M. G. . . . .	Assam Bengal Railway. District No. III. Near Noriani. Mile 479-44 to 479-2.	November 1915 .	5th March 1921.	86	38	10	17	151
						These sleepers have a distinct tendency to crack. No rot or white ant attack but not a very satisfactory lot.				
2	<i>Terminalia myricarpa</i> (Holloek).	89 M. G. . . . .	Ditto	December 1915 .	Ditto	73	10	1	6	89
						A very good lot of sleepers sound in all respects.				
3	<i>Allocarpus Chaplasha</i> (Sam).	25 M. G. . . . .	Ditto	Ditto	Ditto	22	1	1	3	25
						Sleepers in very good condition, no sign of splitting though occasional instances of warp.				
4	<i>Altingia excelsa</i> (Jull).	23 M. G. . . . .	Ditto	Ditto	Ditto	21	1	1	2	23
						A good lot of sleepers in all respects.				
5	<i>Magnolia</i> spp. probably <i>Pealiana</i> (Gahori sap).	21 M. G. . . . .	Ditto	Ditto	Ditto	18	1	1	2	21
						A good lot of sleepers.				
6	<i>Cynometra polyantha</i> (Plug).	18 M. G. . . . .	Ditto	January 1916 .	Ditto	14	2	1	2	18
						A good lot of sleepers.				
7	<i>Altingia excelsa</i> (Jull).	42 M. G. . . . .	Ditto	December 1916 .	Ditto	37	1	1	4	42
						A very good lot of sleepers, though 2 showed signs of dry rot.				
8	<i>Dipterocarpus pilosus</i> (Hollong).	142 M. G. . . . .	As <sup>10</sup> above. Mile 478-21 to 478-22 <sup>1</sup> .	October 1915 .	Ditto	98	35	1	8	142
						Sleepers in very good condition. No rot or white ant attack. Spike hold good, slight rail cut to be watched. Of the removals 5 were badly cracked and one deteriorated from dry rot.				

APPENDIX NO. VI—*contd.*

Serial No.	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	C	R	Total
9	<i>Dipterocarpus pilosus</i> (Hollong).	49 M. G. . . .	As above. Mile 479-4½ to 479-12	December 1916	5th March 1921	46	1	1	3	49
						A very good lot of sleepers, one showing signs of dry rot.				
10	<i>Terminalia myriocarpa</i> (Holloek).	48 M. G. . . .	Ditto	Ditto	Ditto	44	1	1	3	48
						All in very good condition, one showing signs of dry rot.				

Percentage according to species; Condition after the sleepers have been from 5 to 6 years in the line.

Serial No.	Species.	Period under observation to date of inspection.		A per cent.	B per cent.	C per cent.	R per cent.	Total number of sleepers on which the percentage is based.
		Years.	Months.					
1	<i>Lagerstrœmia parviflora</i> (Sida)	5	3	57	25.2	6.6	11.2	151
2	<i>Terminalia myriocarpa</i> (Holloek)	4 to 5	4 3	85.4	8.0	—	6.6	137
3	<i>Artocarpus Chaplasha</i> (Sam)	5	3	88.0	—	—	12.0	25
4	<i>Altingia excelsa</i> (Jutili)	4 to 5	4 3	89.2	—	1.6	9.2	65
5	<i>Magnolia</i> sp. (Gahori Sapa)	5	3	85.7	—	4.7	9.6	21
6	<i>Cynometra polyantra</i> (Ping)	5	2	77.8	11.1	—	11.1	18
7	<i>Dipterocarpus pilosus</i> (Hollong).	5	5	75.4	18.3	0.5	5.8	101

NOTE.—A—Good in all respects.  
 B—Slightly split, decayed or attacked by white ants.  
 C—Badly split, decayed or attacked by white ants, early rejection expected.  
 R—Rejected.  
 O—Original defect.

## APPENDIX NO. VII.

Record of Indian Sleeper Woods treated in England or America with creosote put in under pressure and then laid in open lines.

Serial No.	Species of timber.	Size and Number of sleepers laid down.	Locality where laid, Mile Number and Number of telegraph posts between which laid down.	Date of laying down sleepers.	Date of last inspection.	SUMMARY OF CONDITION OF SLEEPERS.				
						A	B	C	R	O
1	<i>Dipterocarpus turbinatus</i> (Gurjun) from Andamans.	46 B. G. . . .	Eastern Bengal State Railway. Between Nahati and Kankinara. Mile 22-18½ to 22-19½.	18th June 1915 .	15th March 1921 .	25	15	6		46
						All sleepers in road, those in C class badly cracked. Rail seat and spike holes in good order. No rot or white ant attack.				
2	Ditto	46 B. G. . . .	Eastern Bengal State Railway. Between Phulbari and Dohwanipur. Mile 101-9 to 101-21.	15th August 1915 .	13th January 1920	30	16			46
						Sleepers in good condition, some have developed slight longitudinal cracks, but not worse than Sal. Rail seats do not appear to have been damaged and the screw spikes are still all very firm. One removed previous to 1916 due to cracking. Four removed in December 1916, due to white ant attack and the last removed in 1917, due to the same cause.				
3	<i>Pinus Morinda</i> (Spruce).	6 B. G. . . .	North Western Railway. Near Ranipur. Mile 261-89.	22nd March 1912 .	22nd April 1917					
4	<i>Abies Pindrow</i> (Silver Fir).	6 B. G. . . .	Ditto	Ditto	Ditto					
						Four removed in December 1916, due to white ant attack. Two still in the line. The interesting point is that the rail cut is insignificant, after 5 years in a line over which heavy traffic has passed.				
5	Douglas Fir . . .	100 M. G. laid sap up. 100 M. G. laid sap down.	Assam Bengal Railway. District No. III. Near Moriani. Mile 479-4½ to 479-12.	March 1916 .	..	2	87	11	3	100
						82	12	3	3	100
						Sap wood up. Nearly every sleeper cracked. A remarkable instance of the advantage of laying treated conifer sleepers sap down. The reverse is the case with untrated conifers and broad leaf species. Still better results could be obtained with bearing plates.				

NOTE.—A—Good in all respects.  
B—Slightly split, decayed or attacked by white ants.  
C—Badly split, decayed or attacked by white ants, early rejection expected.  
R—Rejected.  
O—Original defects.









Graphic Curves showing the rise and fall in Prices of Sleepers.  
Since 1907

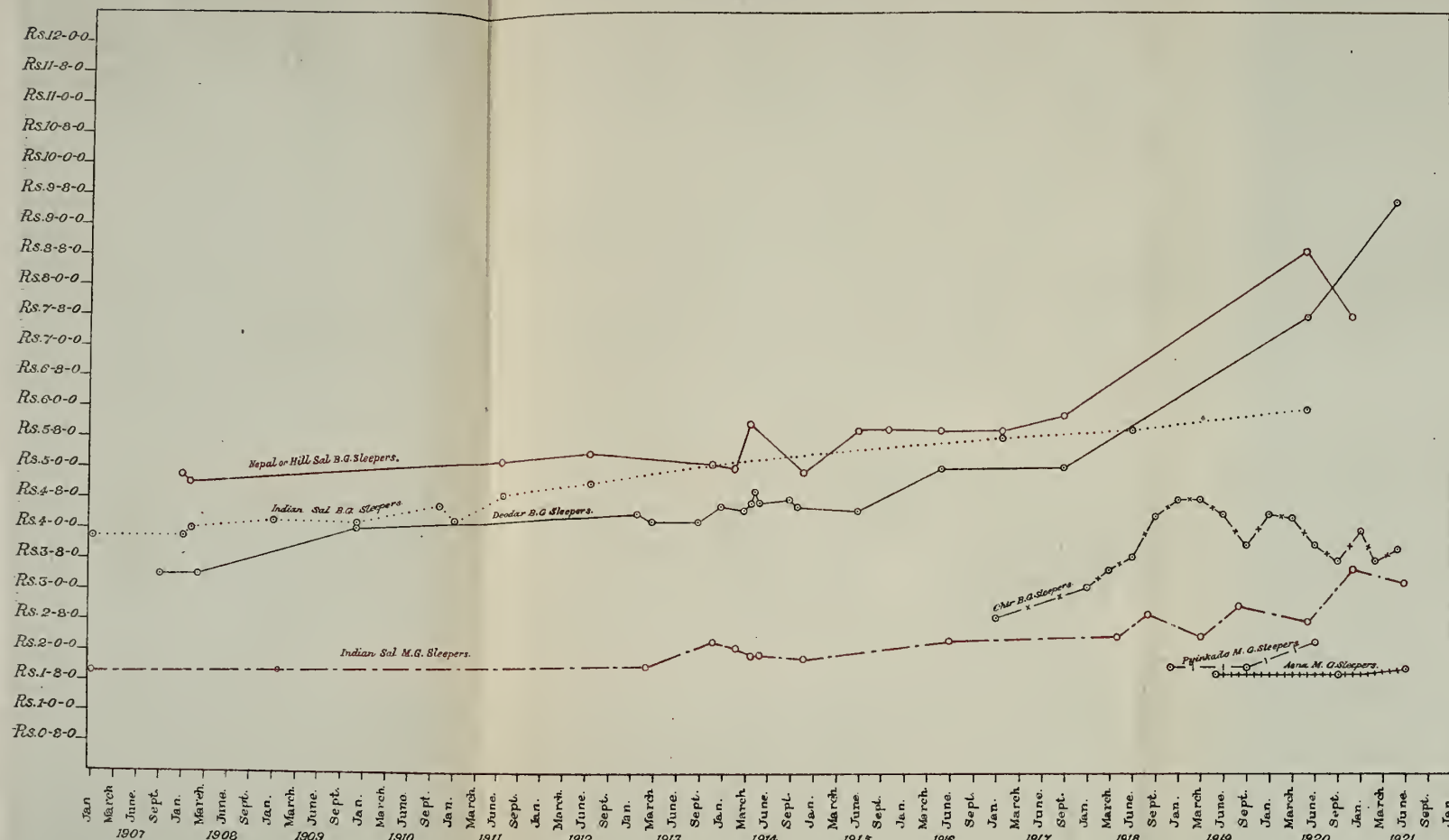
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 \_\_\_\_\_ Nepal Sal  
 — Scantlings.

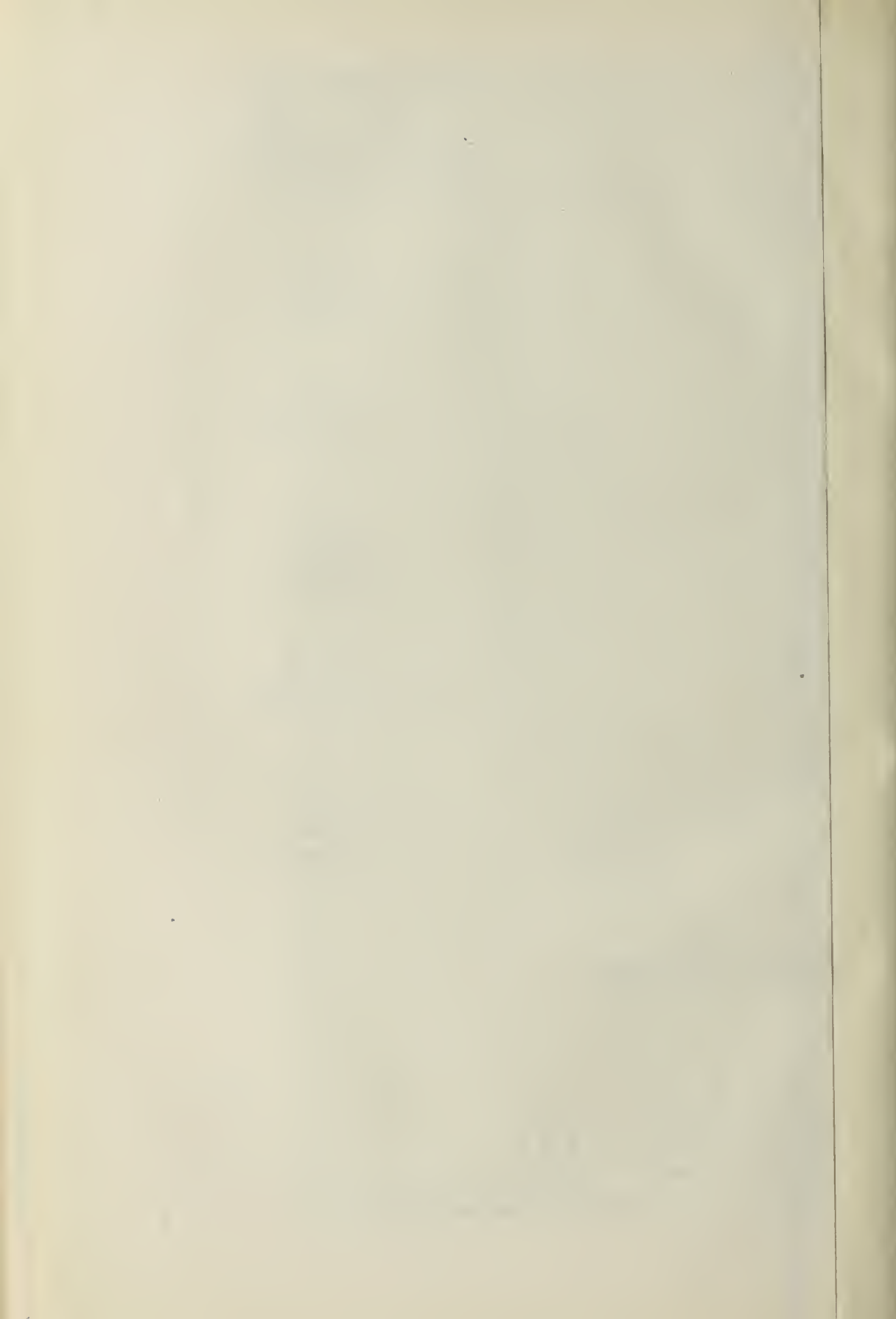
3 c.ft. of  
 \_\_\_\_\_ Deodar Scantlings.

3 c.ft. of  
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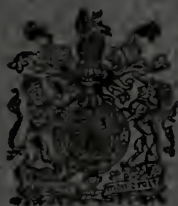
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RECORDS

ON CHALCIDOIDEA.

(Mainly bred at Dehra Dun, U. P., from pests of *Sal*,  
*Toon*, *Chir* and *Sundri*).

By

JAMES WATERSTON, M.A., B.D., D.Sc.



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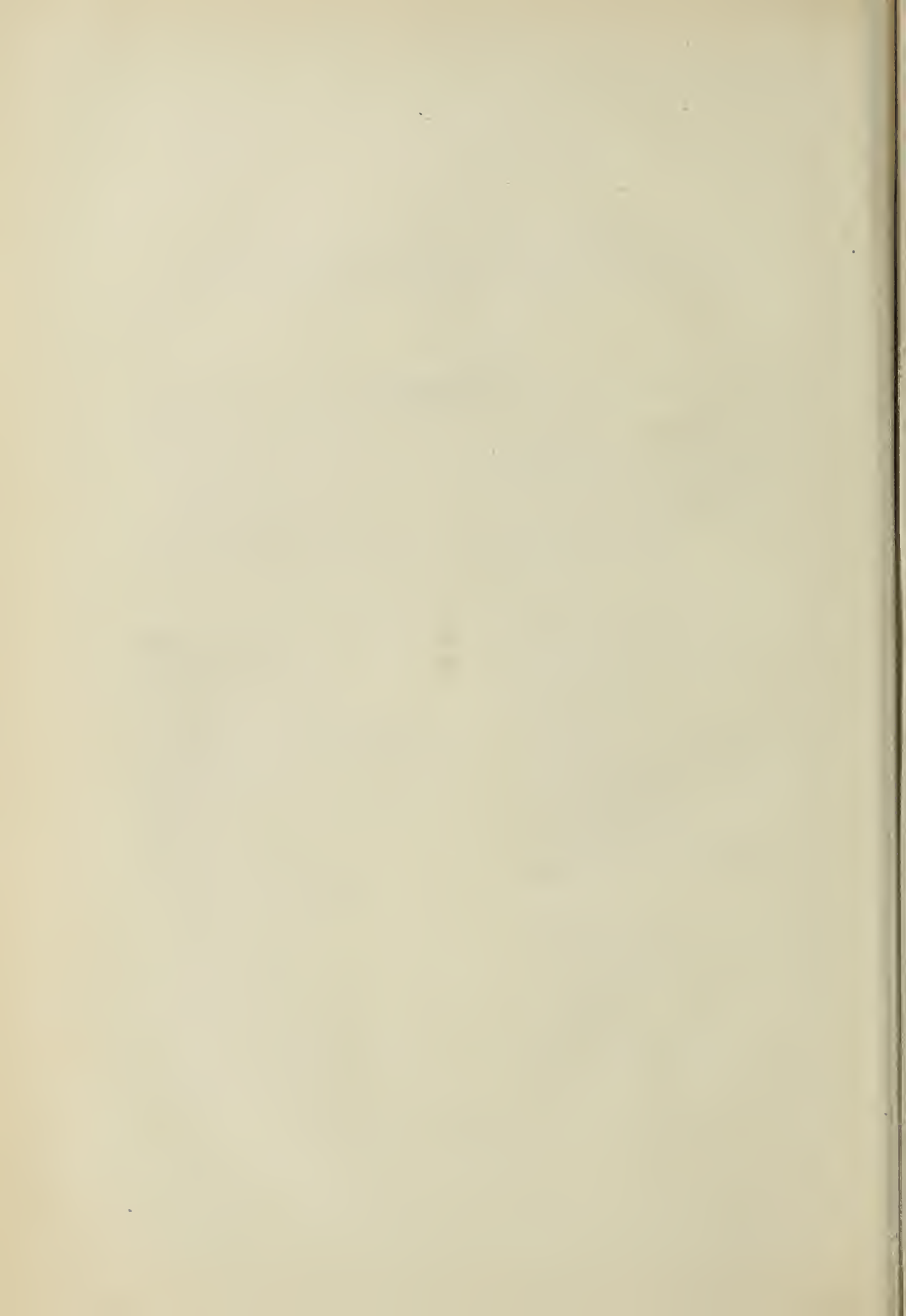
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## INTRODUCTION.

THE Chalcidoidea dealt with by Dr. James Waterston of the Imperial Bureau of Entomology, London, in this Record comprise species that are associated with insect pests of several important Indian timber trees, together with 5 species of which the hosts are not yet known. The material on which Dr. Waterston is now engaged includes parasites or hyperparasites of the chir pine scale-insects, the lac insect, the beehole borer and various wood-boring larvæ.

### Host-relationship.

The host-relationship of the species described is as follows :—

#### LEPIDOPTERA.

- Host. *Hypsipyla robusta* Moore, the Toon Shoot and Fruit Borer.  
*Chaleis tachardiæ*; *C. hearseyi* var *xanthotenus*; *Antrocephalus destructor*; *A. renalis*; *Tetrastichus spirabilis*.
- Host. A Lymantriid moth.  
*Chaleis marginata*.

#### COLEOPTERA.

- Host. *Chrysobothris* (in company with *Glenea*, *Derolus discicollis* Gah. and *Diorthus simplex* White) wood-borers of *Heritiera Fomes*.  
*Trigonura ruficaudis*.
- Host. *Chrysobothris* (in company with *Glenea*, and *Ozotomerus maculosus* Perr.) wood-borers of *Heritiera Fomes*.  
*Trigonura tenuicaudis*.
- Host. *Platypus uneinatus* Blandf., a shot-hole borer of *Heritiera Fomes*, *Shorea robusta*, *Vateria indica*, *Terminalia tomentosa*, etc.  
*Monacon abruptum*.
- Host. *Diapys furtivus* Samps., a shot-hole borer of *Shorea robusta*, etc.  
*Monacon productum*.
- Host. *Ips longifolia* Stebb., the large pine bark-beetle of *Pinus longifolia* and *Pinus excelsa*.  
*Roptrocerus sulcatus*.
- Host. ? *Caryoborus gonagra* Fab., the seed-weevil of various leguminous trees.  
*Oedaule stringifrons*.

## HYMENOPTERA.

Host. A leaf-cutting bee.

*Monodontomerus trichiophthalmus*.

**Biology.**

No special study has been made of the biology and economic importance of the parasites, and, as the following notes indicate, it is probable that they play a minor rôle in controlling the incidence of their hosts.

## HYPSIPYLA ROBUSTA.

The seasonal history of the fruit and shoot borer of *Cedrela Toona* has been worked out in the Dehra Dun district, where it exhibits a succession of five generations in the year.\* In the first two broods (the flower and fruit generations) the larva is exposed to parasitism, but in the succeeding three broods it is more or less protected in a burrow in the woody shoot. The incidence of parasitism is, however, very low throughout the season.

The caterpillars of the first two generations are attacked by a small braconid, of which 12-17 individuals develop in one *robusta* caterpillar. In 1916 when several thousands of *robusta* were reared, the parasitism by the braconid scarcely exceeded 1 per 1000; and in 1920 and 1921 it was not obtained in the breeding-cages. The pupæ of the first two broods serve as hosts for *Chalcis hearseyi xanthotenus*, *C. tachardiæ* and an undetermined species of *Chalcis*, one individual developing in each pupa with a life cycle of 2-3 weeks. All these species have alternate hosts locally, and from the low degree of their occurrence in *robusta*, it appears that the latter is not the preferred host. *Antrocephalus destructor* and *Antrocephalus renalis* are pupal parasites of these broods, *renalis* occurring the more numerously. A few individuals of *Compsilura concinnata*, *Zygobothria gilva* and *Sturmia* near *biseriata*, (Tachinidæ) have been bred from these broods.

In the shoot generations occurring during the rains and cold weather parasitism is due to the above mentioned species of *Chalcis*, to *Tetrastichus spirabilis*, *Rhyssa* sp. near *persuasoria* and to other unidentified *Ichneumonids*.

The chain of parasitism of the toon borer (in the Dehra Dun district) is thus very weak, and exerts but a feeble check on its seasonal abundance. In 1921, when a special attempt was made to determine the abundance

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\* Vide Beeson, C. F. C., Indian Forest Records, vii, 7, 1919. *The Life History of the Toon Shoot and Fruit Borer*, *Hypsipyla robusta* Moore.

and periodic occurrence of parasites, only one species was recovered, *Antrocephalus destructor*, at the rate of .05 per cent. The highest degree of infestation by *Rhyssa* occurred in 1920, viz., 8 per cent. in the fifth generation. The numbers of the borer appear to be controlled far more appreciably by differences in the climatic conditions, partly by the direct effect of the summer heat and the monsoon rains on the insect, and partly by the indirect effect on its food-supply, due to variation in the periods of flowering and leaf-flush.

#### PLATYPODIDÆ.

For the last 10 years Platypodidæ have been bred in the Dehra Dun Insectary from hundreds of species of forest trees, but the experiments have very rarely yielded hymenopterous parasites. The natural enemies of the Platypodidæ are chiefly predaceous beetles, e.g. Histeridæ, Colydiidæ, Cucujidæ. The records obtained for *Diapus furtivus* and *Platypus uncinatus* include only three cases of parasitism by Chalcidoidea, species of the new genus *Monacon*. It is difficult to understand how infection occurs, for conditions inside the gallery-system of a shot-hole borer are not favourable for the development of internal parasites, until the male beetle guarding the entrance hole has been removed, and the activity of the larvæ has been succeeded by pupal quiescence.\* The parasite presumably enters the galleries of the shot-hole borer and oviposits direct in the host larva or pupa.

#### SAPWOOD AND HEARTWOOD BORERS.

The genus *Trigonura* is parasitic on wood-borers, while the larvæ are working in the bark and sapwood. Species including *ruficaudis* and *tenuicaudis* have been bred out from *Heritiera Fomes* in company with *Chrysobothris*, *Diorthus simplex*, *Derolus discicollis*, *Gelonætha hirta*, *Ozotomerus maculosus*, and *Glenea*; from *Shorea robusta* with *Chrysobothris*, *Xylotrips flavipes*, *Ozotomerus maculosus*, *Chlorophorus* and *Euryphagus lundii*; from *Pterocarpus marsupium* with *Buprestidæ* and *Sinoxylon crassum dekkanense*; from *Amoora rohituka* with *Chrysobothris*, *Epania* and *Coptops lichenea*. The species of *Chrysobothris* is a not uncommon and widely-spread sapwood borer, but up to the present no pure infection of this insect has been obtained.

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\* Vide Beeson, C. F. C., Indian Forest Records, vi, 1, 1917. *The Life-History of Diapus furtivus* *Sampson*.



## IPS LONGIFOLIA.

It is of interest that the bark-beetle of Himalayan pines is parasitised by a species of *Roptrocerus*, a genus that is an enemy of *Ips* in Europe and North America.

\*

\*

\*

The illustrations are by Mr. A. J. Engel Terzi, Natural History Museum, London, with the exception of figures 8, 11 and 20, which are by B. Jung Bahadur Singh, Forest Entomologist's Artist.

C. F. C. BEESON,

*The 1st October 1921.*

*Forest Entomologist.*

# INDIAN FOREST RECORDS.

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Vol. IX,

1922

Part II,

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## ON CHALCIDOIDEA.

(Mainly bred at Dehra Dun, U. P., from pests of *Sal*,  
*Toon*, *Chir* and *Sundri*.)

BY

JAMES WATERSTON, M.A., B.D., D.Sc.

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The scope of the present paper is sufficiently indicated by its title and little need be said by way of introduction. It is concerned with the more miscellaneous portion of a collection of Chalcidoid parasites forwarded for determination by the Forest Zoologist in 1915 and 1916. The material not presently noticed, consisting largely of parasites bred from Coccidæ (*Ripersia resinophila* Green, *Tachardia lacca*, etc.) will it is hoped be dealt with in a second paper.

The subjoined list gives the species now noticed or described.

## CHALCIDOIDEA.

*Monodontomerus trichiophthalmus* Cam.

*Chalcis bilobata* Cam.

„ *atridens* sp. n.

„ *tachardiæ* Cam.

„ *hearseyi* Kirby var. *xanthoterus* nov.

„ *marginata* Cam.

*Trigonura ruficaudis* Cam.  
 „ *tenuicaudis* sp. n.  
*Antrocephalus destructor* sp. n.  
 „ *renalis* sp. n.<sup>†</sup>  
 „ *humilis* sp. n.  
 „ *phaeospilus* sp. n.  
*Haltichella macrocerus* sp. n.  
*Monacon productum* sp. n.  
 „ *abruptum* sp. n.  
*Oedaule stringifrons* sp. n.  
*Roptrocerus sulcatus* sp. n.  
*Tetrastichus spirabilis* sp. n.

### Family TORYMIDÆ.

Genus *MONODONTOMERUS* Westw.

#### *Monodontomerus trichiophthalmus* Cam.

*Paroligosthenus trichiophthalmus*, Cameron, Ind. For. Rec. IV, pt. II, pp. 4-5 (1913).

3 ♀♀ Dehra Dun, United Provinces.

“Parasitic on leaf-cutting bee” em, 17. V. 1911.

♂ Dharmoti, Kumaon, United Provinces.

“Taken on wing” A. D. Imms, 8. VI. 1912.

The above have been compared with a cotype in the B. M. collection. The precise host attachment of the type was (loc. cit.) unknown, “From a cocoon out of Sal Tree.” Now that this is more definitely established *M. trichiophthalmus* is found to be in agreement with its European congeners. *Paroligosthenus* Cam. is in my opinion an exact synonym of *Monodontomerus* Westw., and Cameron’s species approaches the genotype *M. obscurus* Westw., (Phil. Mag. (3), vol. II, p. 443. 1833) very closely. Cameron believed *Monodontomerus* to possess “bare eyes” but in all the European examples of the genus which I have examined these organs are densely pubescent though the pile varies in length.

### Family CHALCIDIDÆ.

In this family the tibia is, viewed from the side, obliquely truncated, the apex ventrally being produced into a point sometimes of considerable length, below the first tarsal joint, and hollowed dorsally to receive

the single spur. The surface of the latter is more or less frayed or densely pilose. Viewed from below the apex of the tibia more or less conceals the spur.

In the *Haltichellidæ* the hind tibia is abruptly truncate with two smooth spurs which are plainly visible from below where they are not exceeded by the short apex of the tibia.

#### Genus *CHALCIS*.

In spite of the attempts made to divide it, this genus still remains compact though comprising numerous species. For the purpose of subdivision the antennal formula is useless when once it has been recognised that the funicle consists of a ring joint, seven other joints and a club which may appear to be from 1 to 3 jointed. Mr. J. C. Crawford in an excellent paper on the Chalcidoid parasites of the Gipsy Moth (Bull. No. 19, Pt. II, United States Department of Agriculture, Bur. of Ent. 30. IV. 1910) has indicated some of the essential characters for certain groups of species within the genus.

At least two of these groups are represented in the present collection which includes five species of the genus. In the '*minuta*' group, of which *bilobata* Cam., may be taken as a representative, the antennæ are stout (fig. 4) the second normal funicular joint being transverse, both mandibles are bidentate, and both keels rising from the genal keel, are strongly marked (fig. 3). The hind coxa (♀) is simple.

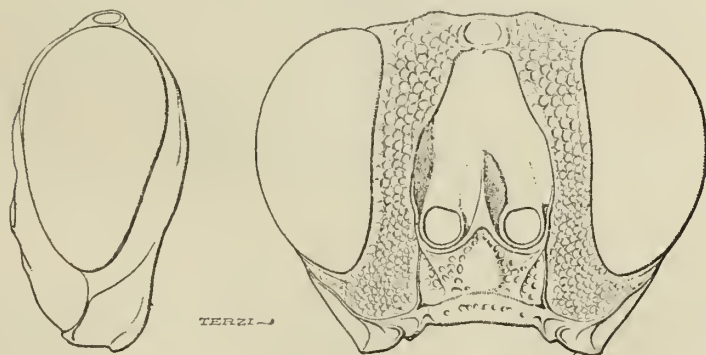


Fig. 1. *Chalcis marginata* Cam. (♀).  
Head, front view and profile.

In the 'marginata' group the antennæ (fig. 2, a) are more slender (the 2nd normal funicular not broader than long) the right mandible

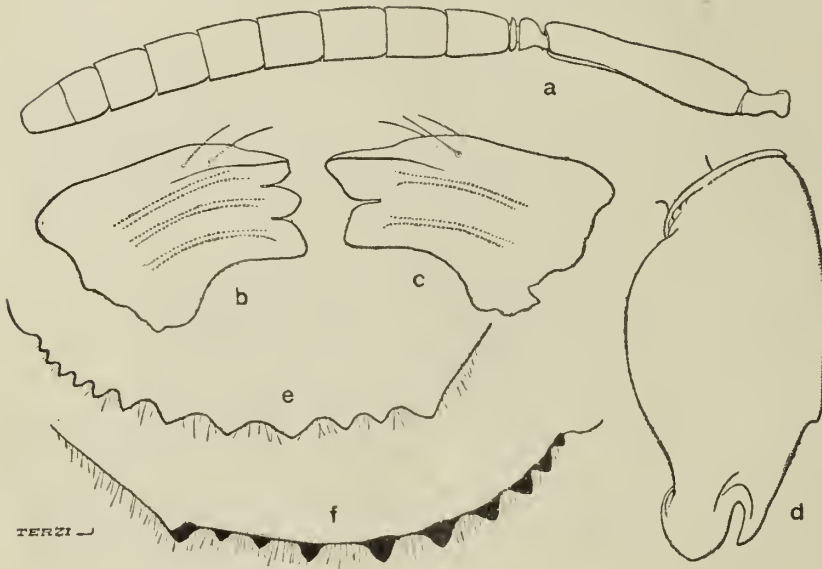


Fig. 2. *Chalcis marginata* Cam. (♀).

a. antennæ.

b & c. mandibles.

d. hind coxa.

e. ventral edge of hind femur.

f. *Chalcis atridens* Waterst. ♀

ventral edge of hind femur.

being tridentate (fig. 2, b) while the anterior of the keels rising from the genal keel is absent (fig. 1). The hind coxa bears a ventral subapical tooth (fig. 2, d). Between the toruli and the clypeus there is a smooth area bounded by more or less pronounced lateral keels (fig. 1). Cameron has made *C. marginata* the type of a genus *Oncochalcis*. (The Entomologist p. 161, 1904), but his subsequent application of the category has been loose and inconsistent.



***Chalcis bilobata* Cam. (Figs. 3 & 4).**

*Chalcis bilobata* Cameron (P) Zeitschr. Hym. u. Dipt. V, p. 283 (1905).

Three examples from Kumaon Himalayas, United Provinces, as follows:—

♂ “on undergrowth,” nr. Bhowali, 6,000 ft. 11th May 1912.

♂ “by sweeping,” Peora, 5,500 ft. 11th June 1915 (C. F. C. Beeson).

♀ “on wing”, Bhim Tal (Naini Tal Dist.) 4,800 ft. 10th May 1912.

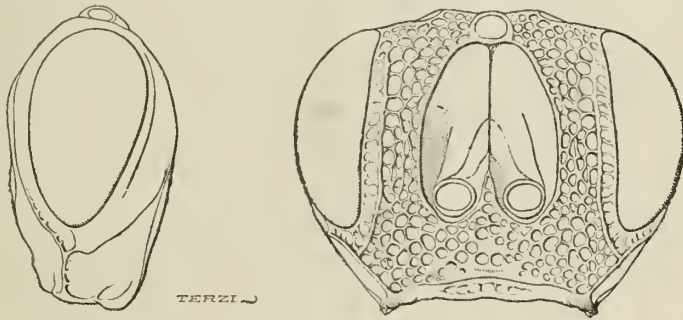


Fig. 3. *Chalcis bilobata* Cam. (♀).  
Head, profile and front.

This form belongs to the group of the genotype *C. minuta* L. (1767). In typical *minuta* (Europe) the wings, especially in the female, are definitely infumated, the post-spiracular, dorso-lateral tooth on the

propodeon is conspicuous and nearly erect, and the tubercle on the inner aspect of the hind femur near the base is well developed.

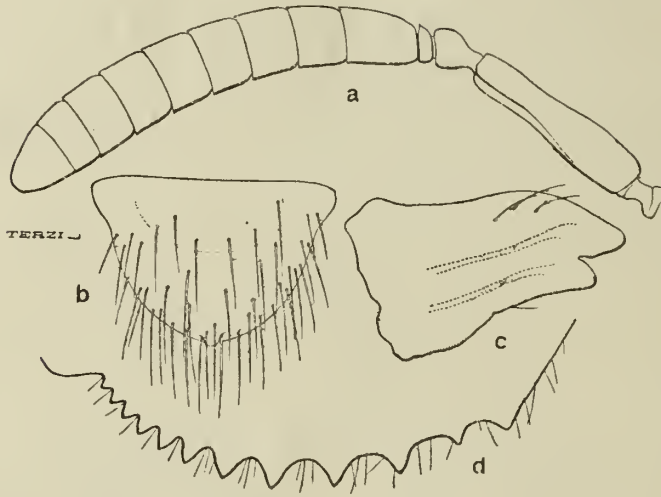


Fig. 4. *Chalcis bilobata* Cam. (♀).

- a. antennæ.
- b. labrum.
- c. mandible.
- d. ventral edge of hind femur.

In the above Indian examples the wings are paler, (nearly hyaline in the male) the propodeal tooth low and somewhat flattened while the inner femoral tubercle is inconspicuous. In *C. paraplesia* Crawford, (loc. cit. p. 19, figs. 22-23) the wings in both sexes are hyaline and the femoral tubercle is distinct. Otherwise this Japanese form is extremely close to the genotype and to *bilobata*. *C. fulvitaris* Cam. (Journ. Bombay Nat. Hist. Soc. XVII, p. 94, 23, IV. 1906) appears to be only a colour variation of *bilobata*.

***Chalcis atridens* sp. n. (Fig. 2, f).**

♀. Body and coxæ black, scape narrowly at base and apex above (but nowhere medianly) dark brown, tegulæ basally brown, apical  $\frac{2}{3}$

yellow, pubescence generally whitish but yellowish at apex of abdomen. Wings very faintly embrowned. Legs, all tarsi pale with a faint reddish tinge especially distally. Fore femora up to  $\frac{2}{3}$ , mid femora up to  $\frac{3}{4}$  from base nearly black, thereafter brownish and yellow at the extreme tip. Fore tibia yellowish or yellowish brown with a darker spot towards the middle externally; mid tibia, blackish brown, paler at base and more broadly at apex. Hind femur ferruginous with a dark spot externally towards the base and paler at the extreme apex ventrally in front of the insertion of the tibia. This pale spot does not nearly reach the edge dorsally and its limits are indefinite. Femoral teeth black (fig. 2, f).

The hind tibia is mainly concolorous with the femur, but the apical  $\frac{1}{4}-\frac{1}{5}$  is yellowish white and the ventral edge blackish.

Head of the '*minuta*' type with stout antennæ. Between and below the toruli the surface to the clypeus is entirely smooth but without lateral ridges or keels. Mandibles both bidentate, apically contracted, the teeth short and rounded, scutellar plate well developed and broadly incised in the middle. No prominence or tooth *dorsally* behind the spiracle on propodeon, no tooth on hind coxa. Hind femur externally with strong not very closely set punctuations. No basal tubercle on inner aspect. Teeth 10 in number, the first at about  $\frac{1}{3}$  from the base, large, followed by two smaller, the next five are subequal to the first. The first 6 teeth are widely spaced (fig 2, f). Abdomen, 1st tergite entirely smooth and polished, 2nd with numerous punctures at the sides but reduced across the middle to a single row. Distally this tergite is dimmed and roughened the surface being raised into many very minute chitinous points. Succeeding tergites smooth basally but with transverse rows of strong punctures apically. Length barely 6 mm., Alar expanse 12 mm.

Type ♀ in British Museum.

"Taken on grass," Dehra Dun, United Provinces, 22nd April 1915.

This species belongs to the '*fonscolombi*' section of the '*minuta*' group. In *C. fonscolombi* Dufour (Ann. Soc. Ent. France X, p. 16, 1841) there is an incipient tooth behind the spiracle at the side and a well developed basal tubercle on the inner aspect of the hind femur. As regards colour the tegulæ in the European species are entirely yellow, the hind coxæ piceous or black at the base and more ferruginous towards the tip. The yellowish apical spot on the hind femur reaches the dorsal edge and there are two yellow bands (one sub-basal, the other apical) on the hind tibia. There is also generally but not invariably a pale anterior (ventral) median spot on the scape.

***Chalcis tachardiæ* Cam.**

*C. tachardiæ* Cameron, The Indian Forest Records, Vol. IV, Pt. II, p. 3 (January 1913).

One female, bred from pupa of *Hypsipyla robusta* Moore, Dehra Dun, United Provinces, 11th May 1915 (C. F. C. Beeson) (April-May, 1916, N. C. C.)

This represents another group close to that of '*marginata*.' The right mandible is tridentate, the smooth subtorular area is without defined margins and the general facial punctuation is rather shallow. The keels parallel to the orbits are distinct on the face but fade out towards the genal keel and there is no tooth on the hind coxa.

***Chalcis hearseyi* var. *xanthotenus* nov. (fig. 5).**

*Chalcis hearseyi* Kirby, Journ. Linn. Soc. Lond Zool. XVII, p. 76 (1883)

♀. Black, Wings hyaline, (veins of forewing blackish brown, of hind-wing yellow on anterior proximal half). Tegulae, apical  $\frac{1}{4}$  of fore femora, apical  $\frac{1}{5}$  of mid femora, fore and mid tibiae and all the tarsi bright yellow or yellowish. Hind femur with apical spot which is yellow dorsally and yellowish white ventrally. Hind tibia with a narrow blackish brown basal ring opposite the apical femoral spot, and infuscated ventrally and along the inner ventral aspect to  $\frac{1}{4}$  from the apex. Otherwise yellow.

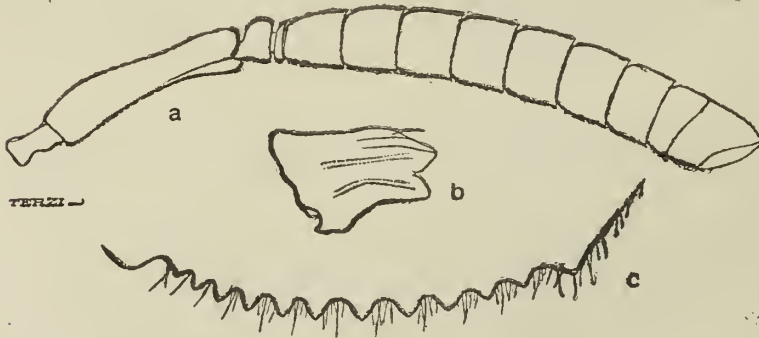


Fig. 5. *Chalcis hearseyi* var *xanthotenus* Waterst. (♀).

a. antennæ.

b. mandible.

c. ventral edge of hind femur.

♂. Hind tibia infuscated on outer aspect as well to about  $\frac{1}{2}$  its length, the inner and outer infuscations hardly meeting dorsally. Head, the malar keel gives off one keel backwards, the preorbital keel being absent. There is a narrow triangular smooth supra-clypeal area. Mandibles both bidentate, the teeth equal and spreading (fig. 5, b,) 2nd normal funicular joint practically quadrate (fig. 5, a). Scutellar plate only slightly bilobed. No tooth on propodeon behind the spiracle and no tubercle on hind coxa.

Type of var. *xanthoterus* ♀ in British Museum.

One of a series ♂, 9 ♀♀ ex pupa *Hypsipyla robusta* Moore, em. Dehra Dun, United Provinces, 17th October 1913, C. F. C. Beeson [18th April 1916, N. C. C.; ex pupa of *Euploca* on leaf of *Nerium odorum*, Dehra Dun, 10th October 1918, C. F. C. Beeson].

In typical *hearseyi* ♀ the hind femur is completely infuscated to  $\frac{2}{3}$  from the base. The single ♂ from the type locality (Barrackpur, Calcutta) seems to me indistinguishable from the Dehra Dun specimen of this sex.

In colour and general facies this variety of *C. hearseyi* Kirb. looks like a small form of *C. marginata* Cam. but the two can be readily separated by the characters noted, (cf. figs. 5 and 2, a-e).

### ***Chalcis marginata* Cam. (Figs. 1 and 2).**

*Oncochalcis marginata* Cameron P. (The Entomologist, p. 162, 1904). ♂ and 2 ♀♀ from Dehra Dun, United Provinces, 8th May 1915 (C. F. C. Beeson), one ♀ bred ex pupa of Lymantriid; the others taken on the wing.

*Oncochalcis* (l.c. p. 161) as defined by Cameron is full of inaccuracies and trivialities. Interpreted by its type, the category applies only to a section of the genus *Chalcis*. The carinae of the head and the characters of mandibles and hind coxae are the most reliable guides to the recognition of this group. It should be noted however that, particularly in badly nourished examples, the sculpture of the head may be feebly developed and the keels difficult to make out. The tooth on the hind coxa may be practically absent though the angulate ventral edge is never lost. There is also a tendency for the left mandible to develop a minute denticle in the angle between the apical teeth.

In Europe the representative form of this group is I believe *C. intermedia* Nees. (1834).



Genus *TRIGONURA* Sich.***Trigonura ruficaudis* Cam. (Fig. 6).**

*Centrochalcis ruficaudis* Cameron, Ind. For. Rec., IV., Pt. II, p.,2 1913.

There is a double confusion in the original generic placing of the above species. (A) Cameron erected *Centrochalcis* (loc. cit.) for this true Chalcidine form, ignoring the fact that he had already (Zeitschr. f. Hymn. Dipt. p. 230, 1905) used the name for a Haltichellid species. If *Centrochalcis* therefore is to stand at all it must be in the latter family; (B) apart from the name being preoccupied *Centrochalcis* (1913) appears to me to have been unnecessarily created. Cameron recognised that the insect presently under discussion runs down to "near *Trigonura* and *Thaumatella* (sic.)" (l.c.) presumably *Thaumatelia*, but apparently thought it needless to discuss the claims of these genera on the ground that they are Neotropical. I have elsewhere queried the soundness of this reasoning (Bull. Ent. Res. Vol. VI, Pt. IV, p. 384, 1916) and a more thorough examination of *C. ruficaudis* made possible by the material mentioned below, left me convinced that *Centrochalcis* Cam. (1913) must be an exact synonym of *Trigonura* Sich. Mr. Crawford, who subsequently kindly examined a female at my request, is of the same opinion. The synonymy of *Centrochalcis* therefore reads

## Family HALTICHELLIDÆ.

*Centrochalcis* Cam. (1905).

## Family CHALCIDIDÆ sens. str.

*Centrochalcis* Cameron (1913) *Trigonura* Sichel, (1865) nec. Cameron (1905).

Some additional notes and corrections may be made on Cameron's description :

Head. Mandibles tridentate (Fig. 6, *b*), similar; labrum small, with 10 major bristles connected with sensorial channels and some others more minute. Trophi. Maxillæ; stipes with over 40 bristles behind the palpus and 6 much longer in a transverse row towards the mid line. Joints of palpus in ratio 3 : 5 :  $4\frac{1}{2}$  : 9. The second joint broad (2) at apex. About 16 sensory spines fringing lingua. The mentum bears only 2 central bristles just behind the palpi. The surface both of the stipes and mentum

is smooth with at most faint indication of longitudinalæ stri. Antennæ 12-jointed. Cameron failed to notice the distinct division of the club.

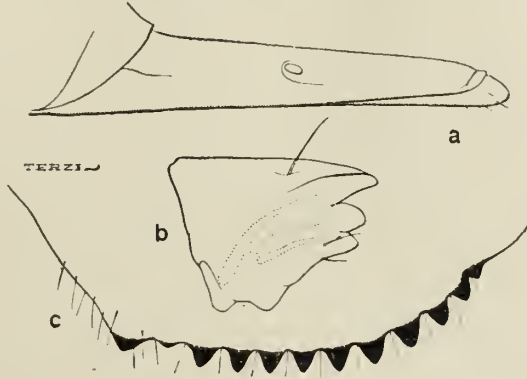


Fig. 6. *Trigonura ruficaudis* Cam.(♀).

a. ovipositor.

b. mandible.

c. hind femur, ventral edge.

The formula is :—

scape, pedicel, single ring joint, 7 in funicle, and 2 in club. Scape, averaging 9 : 1 and at its widest (15 : 2) near the base rather longer than the sum of pedicel, ring joint, and first two of the funicle. Pedicel  $\frac{1}{6}$  of the scape. Funicle 1-3 equal (35) 4-5 equal (30) 6-7 diminishing 27-25. The club (38) is equally divided. In the same ratio the breadth is 11-12. The sensoria occurring from the 1st normal funicular joint onwards are numerous, appressed, and cover the joints like scales. The base is narrow, oval, and the projecting flange as long as the base. On the club and apical half of the last funicular, the sensoria have no projections. The ring joint with a complete row of short bristles—(not bare C.). Total length of antenna 3.75 mm.

Wings. Forewings nearly three times as long as broad, length 3.8 mm. breadth 1.3 mm. Submarginal : marginal 4 : 1. Postmarginal and radius equal, and each  $\frac{1}{4}$  of the marginal. Below, the submarginal cell bears numerous short bristles on the basal  $\frac{1}{3}$ . From  $\frac{1}{3}$  from the base to  $\frac{1}{5}$  from the apex a number (about 14) of bristles gradually increasing in length form a row for its first half parallel to the costa and on the second sloping across the cell. The apical  $\frac{1}{5}$  of the cell is bare but before this the extreme costa bears 8-10 minute bristles, submarginal with 25-27 bristles. On the marginal, postmarginal, radius, and then in a narrowing band

reaching to near the apex, are numerous short bristles. On the sub-costal area between the root of the marginal and the radius, the bristles are rather sparser. Up to half the submarginal, the basal triangle is practically bare and the general wing surface, even counting both sides shews a scattered and not very regular pile. From the end of the radius a narrow belt of bristles (2-3 deep) runs back towards the radix parallel to the marginal vein as far as the origin of the latter. Between this belt and the more closely set bristles on and near the marginal, is an elongate bare space on the upper surface. From the radius there runs to the apical edge a row of isosclinal bristles (at places ill defined) with a narrow bare line on both sides. This line meets the outer edge about  $\frac{1}{3}$  behind the apex. A second isosclinal row rising about the middle of the wing below the radial knob, runs at first parallel to the costa and then bends round parallel to the 1st isosclinal row, finally meeting the outer edge at  $\frac{1}{2}$ . Hindwings  $3\frac{1}{2}$  times as long as broad, length 2.5 mm., breadth 7mm. 9-10 bristles at apex of submarginal cell. About 17 spinose bristles in comb on vein at the hooks.

Legs. Forelegs, tarsal comb of 25 thin spines and 3 stouter continue the comb to the apex. Apex of hind tibia with comb of 17-18 spines. Tarsal ungues of forelegs with two, mid and hind with 3 thin flat teeth basally.

Proportion of tarsal joints :—

—	1	2	3	4	5 (without claw).
I . . . .	12	7	5	4	8
II . . . .	12	8	6	4	10
III . . . .	7	6	$5\frac{1}{2}$	4	10

Of this species 3♂♂ and 5♀♀ have been submitted, bred out of "Sundri" *Heritiera Fomes* Buch. attacked by *Chrysobothris* sp. [Buprestidæ] in company with *Glenca* [Lamiidæ] *Derolus discicollis* Gah. and *Diorthus simplex* White [Cerambycidæ] Sunderbans, Bengal. Emerged Dehra Dun, in June 1911.

#### **Trigonura tenuicaudis** sp. n. (Fig. 7).

Head, pronotum medianly, remainder of the thorax except narrowly at the sides of the mid lobe of the meso-notum, abdomen and apical half of ovipositor black or blackish brown. Pronotum (mainly) and sides of the mid lobe rufous, tegulæ brownish, basally darker, Scape, pedicel,

last 3 funicular joints and club blackish. The rest more or less rufous. Wings brown tinted, darker round the stigma. Femora and tibiae blackish, knees and tarsi more rufous. Inside of femora obscurely paler. The setigerous tergite which forms rather more than the basal half of the ovipositor, rufous. Pile everywhere whitish.

Easily told by the face and by the long ovipositor which is nearly half as long again (17:12) as the abdomen.

Head. Pronotum with coarser punctuation than in *T. ruficaudis* Cam., and definitely umbilicated on the frons. The intertorular area triangular (*i.e.*, the toruli rather wide apart) and reaching superiorly to about  $\frac{1}{5}$  from the top of the scapal furrow. Below the toruli and above the clypeal edge are two hollows between which the surface is dull. In *ruficaudis* the intertorular area is short with subparallel sides, its upper knife-like edge thinning out before  $\frac{1}{2}$ . The toruli are approximated with no hollows below and between them, and the clypeus is a narrow shining median line. Mouth parts; labrum quadrate with rounded distal angles, *yellowish*, thin and *clear*, with 18-20 fringing bristles. Mandibles (Fig. 7, *b*) hardly longer than broad (7:6), short, thick at base tridentate, all the teeth blunt and rounded, only the basal one clearl

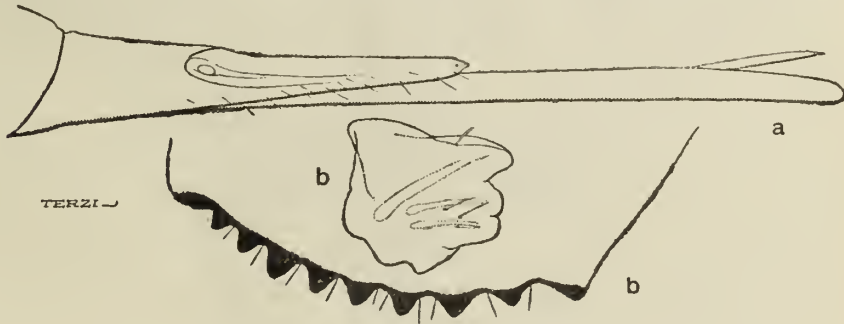


Fig. 7. *Trigonura tenuicaudis* Waterst (♀).

a. ovipositor.

b. mandible.

c. ventral edge of hind femur.

separated, the upper pair like two rounded contiguous lobes. Behind the upper teeth externally is a patch of 12 bristles and behind them again an irregular transverse row of about 6. Maxillae; the stipes is evenly set with very numerous short bristles and there is only a single slightly larger bristle inside. Palpus 3,  $3\frac{1}{2}$ , 4,  $6\frac{1}{2}$ , joints 2-4 (especially the last) shorter than in *ruficaudis* and distinctly broader, the greatest breadth ( $2\frac{1}{2}$ ) occurs on the 4th joint. Mentum with 70-80 bristles; labial palpus much as in *ruficaudis* (*i.e.*, 1 and 3 subequal and each over twice as long



as 2) but stouter. Surface of stipes and mentum distinctly raised reticulate.

Wings. Forewings, length 3.7 mm., breadth 1.3 mm. The ratio of submarginal : marginal : radius : postmarginal is approximately 10 : 3 : 1 : 1 the ratio between postmarginal and radius more accurately 14 : 17 while the marginal is about  $2\frac{1}{2}$  times the radius. The radius is distinctly longer, not so sessile, more pedunculate than in *ruficaudis*. In the subcostal cell the bristles are much more numerous than in *ruficaudis*. At the costa, they stand (minute) 2-3 deep along the entire length, and (also on the underside) there are numerous longer bristles on the apical third of the cell. The bristles of the basal half of the cell are tinted and stronger than in *ruficaudis*. On the disc the bristles are denser and longer, no bare track between apex of radius and base of the marginal.

The first isosclinal row from the apex of the radius, ill-developed and not isolated, is made noticeable mainly because of the darker tint of the membrane along its course. The second is less distinct than in *ruficaudis*. Hindwings slightly narrower, length 2.5 mm., breadth .67 mm. 8 small bristles at the hooks.

Hind legs. Tibial comb ; 12 spines across the apex behind, and 8-9 dorsally along the posterior edge of the apical cleft. The spur is nearly smooth and very short—only  $\frac{1}{5}$ th longer than the spines of the comb and about  $\frac{1}{2}$  the length from its own base to the ventral apical angle of the tibia.

Abdomen, smooth, and shining except where the surface is broken by the insertion of the hairs. The long base of the ovipositor (the 7th visible tergite) shews numerous large setigerous punctures on its basal third. After the process the surface is dull and reticulated. The apex of this segment lies at about  $\frac{1}{2}$ , whereas in *ruficaudis* it extends nearly to the end of the ovipositor (cf. figs. 7, a and 6, a) length, 8-9 mm. (of which the ovipositor is 3.3-4 mm.) alar expanse about 8-9 mm.

Type ♀ in British Museum one of a series of three. Bred out of *Heritiera Fomes* Buch., attacked by *Chrysobothris* (Buprestidæ) *Glenca* (Lamiidæ), *Ozotomerus maculosus* Perr. (Anthribidæ) probably parasitic on the Buprestid. Pupates in the bark in the pupal chamber of the boring larva.

Sunderbans, Bengal, emerged at Dehra Dun, May-June, 1915.

### Family HALTICHELLIDÆ.

#### Genus ANTROCEPHALUS.

#### *Antrocephalus destructor* sp. n. (Figs. 8, 9, 10).

♀. Black ; the abdomen ventrally, near base immediately behind the



petiole, on the area covered by the 2nd (1st visible) sternite and ovipositor obscurely rufous; forelegs castaneous. Hind legs, coxæ blackish-brown, femora externally mainly blackish, more castaneous round the edges, hind tibia castaneous with darker ventral edging, hind tarsi infuscated. Forewings hyaline with 2 large discal spots (see fig. 8).

Head. In profile narrow, malar keel direct to the lower eye with a posterior branch close to and parallel with the orbit. Facial impression very wide extending to the orbits before each of which is a low preorbital keel extending downwards towards, but fading off before, the malar



Fig. 8. *Antrocephalus destructor* Waterst (♀).

keel. The punctuation is moderate, finer than on thorax. Antenna, length 3.5 mm., scape, length 1.1 mm. elongate, slender, near the base with a breadth 1 : 8, at the apex 1 : 7, pedicel (5 : 2) slender, a little over  $\frac{1}{4}$  of the scape. Funicle 8 joints all cylindrical although the first (the here normally developed ring joint) is just longer than broad; after the first the proportions of the joints are approximately (2 and 3) 6,

(4), 5, (5 and 6),  $4\frac{1}{2}$ , (7), 4, (8),  $3\frac{1}{2}$ . Taking the last joint as 70 the uniform width from 3-8 is 60, 2 (57), and 1 (50). The club, as long as joint 6 of the funicle, shews only 1 distinct suture (at which it is as broad as the funicle) dividing it 5 : 12. There is a small apical sense organ and a minute spatulate spur. The first funicular has an apical row of 3-5 sensoria, the other joints shew 3-5 more or less complete rows containing up to 10 or more sensoria in all of which the flange exceeds the elongate narrow base.

Mouth parts ; labrum transparent brown, broader than long (4 : 3) contracted basally, in general shape parabolic, surface reticulate pattern transverse, at base raised into striae ; about a dozen bristles on the surface and many more stronger (18 : 18) at the sides, at the end of long sensory channels. The median pair of these fringing bristles is over  $\frac{1}{3}$  the length of the labrum. Mandibles (3 : 2) the right tridentate, the left bidentate (fig. 9, *a* and *b*) both apically contracted, the teeth small. In the right, rounded, subequal, the middle one smaller. In the left more truncate. Externally the mandibles bear along the ventral and dorsal edges and subapically, in all 6-7 bristles and on the general surface up to 30 others considerably ( $\frac{1}{2}$ - $\frac{1}{4}$ ) shorter. Cardo narrow, longer than either stipes or galea. Maxillary palpus 7 : 11 : 10 : 16, labial palpus 11 : 4 : 11. Mentum smooth, 14-15 bristles, about 20 sensory bristles on lingua. Thorax ;



Fig. 9. *Antrocephalus destructor* Waterst (♀).

*a.* and *b.* mandibles.

*c.* Hind coxa.

*d.* ventral edge of hind femur.

all notal surfaces densely set with small thimble-like punctures (smooth only towards the sides at the suture between the parapsides and axillæ) the surface between the punctures being also minutely reticulate ; each puncture gives rise to a minute flat glistening white bristle. Pronotum

anterolaterally margined, anteromedianly descending vertically but rounded only. Scutellum slightly exceeding the mid-lobe, 2 short distinct teeth, no longitudinal median depression or sulcus. Pleura; mesopleural femoral impression 10-11 complete ridges and 2-3 incomplete ventrally; on the ventral half of the metapleuron is a dense tuft of short glistening bristles.

Propodeon (see fig. 10).

Wings. Forewings distinctly triangular, not quite 3 times as long as broad. Length 4 mm., breadth 1.4 mm. Submarginal : marginal : postmarginal approximately in ratio 9 : 2 : 2. More exactly the postmarginal is about  $\frac{1}{2}$  longer than the marginal. The radius is sessile, less than  $\frac{1}{5}$  of the postmarginal. Up to  $\frac{4}{5}$  from its origin the submarginal bears about 25 bristles; from this point to the costa the bristles go from 2-4 deep, many of them flattened and scale-like. The short radius bears half a dozen bristles. The submarginal cell is covered with bristles (about 4 rows deep) to half its width from the costa. The basal triangle is bare to about the uprise, but there is a row of minute bristles near to and parallel with the submarginal from about  $\frac{1}{2}$ . The discal ciliation is minute, dense, and regular but (a) on the coloured areas the bristles are longer, stouter, and with a tendency to become scale-like especially behind the marginal, and (b) between the coloured areas is a large roughly circular spot just behind the radius covered by weak thin bristles on both sides of the membrane; (c) the subcostal ciliation from the radius towards the apex is denser. There are no complete isosclinal lines but two are indicated, one about the middle of the wing seen obscurely from the clear spot outwards and not reaching the termen. The second is double, beginning above the middle of the retinaculum and traceable to nearly the level of the outer edge of the outer spot. Hind wings; length 2.8 mm., breadth .9 mm., a dozen bristles in a row at the hooks.

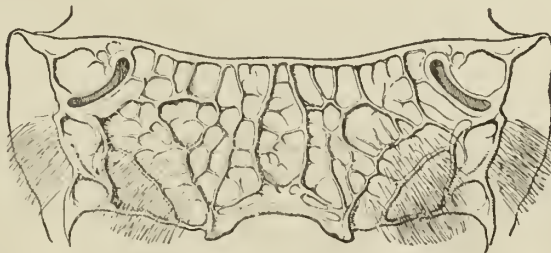


Fig. 10. *Antrocephalus destructor* Waterst (♀).  
Propodeon.

**Legs.** Forelegs, tibia, anteriorly and subdorsally towards the apex one or two of the uniform short bristles which clothe the entire surface are developed into moderate spines, of which 3, wide apart, lie above the insertion of the tarsus. Between these and the tibial spur the comb contains about a dozen bristles or spines which become longer and stronger towards the spur. Tarsal unguis only gently curved with basally, 1 long flat knife-like spine and 2 broad teeth. Mid legs ; tibia anteriorly with about 16 spines, median or submedian, occurring mainly in pairs from  $\frac{1}{2}$  towards the apex. Tarsal unguis as in forelegs. Hind legs, coxa (4 : 3) more oblong than pyriform, in profile the rim above the trochanter forms a right angle and there is a similar angle below the insertion of the joint which may therefore be said to shew 2 blunt teeth on its upper inner edge (see fig. 9, *c*). Femur ; no inner tooth or basal projection. 3 lobes on ventral edge, which is dentate (about 48 teeth) from apex to less than  $\frac{1}{3}$  from base (fig. 9, *d*). The subapical and the median lobes respectively are rounder, the subbasal more pointed and dentate only on the distal side. Tibia ; 2 very short broad peg-like spines anteriorly at the upper apical angle above the insertion of the tarsus. Comb, there are 20-30 long fine spines (stronger ventrally) on the posterior apical edge, but these grade with usual covering bristles of the joint and except near the spurs do not form a well defined comb.

#### Proportions of tarsal joints—

In the fore tarsus the ratio is 30, 18, 13, 10, 21 (ex. claw).

In the second tarsus, joints 2-5 are the same length as in 1, whilst the 1st is 35. In the hind tarsus, the ratio is 11, 12, 10, 9, 12. Abdomen, dorsal view. Segments shining basally, but finely shallowly punctured apically. Tergite 1 (first visible) on apical  $\frac{1}{3}$ . Tergite 2 entirely (*i.e.*, all the projecting portions). Tergites 3-5 are only roughened apically. The 6th is distinctly punctured and rough between the punctures. The 7th is medianly carinate and the surface like that of the ovipositor-sheath is dull. In profile the abdomen is shining basally (overlaps of 1st tergite and basal half of 2nd), but for the most part the sides appear rather coarsely punctured with narrow gleaming bands, *i.e.*, the basal unpunctured parts of the tergite. All these punctures emit short glistening white hairs which are flatter and stronger on tergite 6 (the spiracular). On the ovipositor and its supporting tergite (except just at the base of the latter where the hairs are nearly as strong on tergite 6) the pile is fine. This species varies considerably in dimensions. In one of the average sized examples from which the above wing measurements are taken the length is over 7mm., the alar expanse about  $9\frac{3}{4}$  mm.



♂. Differing from the ♀ mainly in the wings which are completely hyaline except for a brownish edging behind the marginal vein. The abdomen is dorsally dull only the sutures being smooth. Disc of 1st tergite with closely set fine punctures and a patch of coarse setigerous punctures at each side. The other tergites bear 2-3 rows of large punctures with finer ones between. Of colour differences the most conspicuous is in the entirely black funicle.

Length 5 mm. alar expanse  $7\frac{3}{4}$  mm.

Type ♀ in British Museum.

One of a series 2♂♂, 14♀♀ ex *Hypsipyla robusta* attacking Toon (*Cedrela toona* Roxb.) Dehra Dun, United Provinces, May-June 1915, C. F. C. Beeson; [May-June 1921, N. C. C.]

*A. destructor* is closely related to *A. (Stomatoceras) magretti* Kirby, (Journ. Linn. Soc. Lond. Zool. Vol. XX, p. 35, (1880) but in the African species the first (adbasal) of the spots on the forewing forms a complete band while the second extends to nearly three-fourths of the width. The first abdominal tergite is distinctly and densely punctured both on the disc and more coarsely on the overlaps, the whole surface appearing much duller than in *A. destructor*.

### ***Antrocephalus renalis* sp. n. (Figs. 11, 12, 13).**

♀. Black, the last 2 segments of the funicle, the edge of the tegulæ blackish brown. Wings slightly tinted, with a blackish brown spot from the uprise of the marginal vein to the club of the radius and only a little broader at its maximum, than the length of the radius. Tarsi blackish brown, the joints darkest dorsally and paler towards their apices ventrally.

Length 6 mm. alar expanse 10 mm.

In the ♂ the hind tarsi are entirely black.

Length  $5\frac{1}{2}$  mm. alar expanse 9 mm.

This species is the largest and darkest of a group in which the scutellum shews a longitudinal median crenulate sulcus, the crenulation being produced by contiguous umbilicate punctures which elsewhere on the scutellum are more sparsely set with smooth gleaming interspaces. At its posterior end the sulcus divides the apex into two rounded lobes but the scutellar plate is only narrowly developed. The post marginal vein is distinctly longer than the marginal from which a single transverse





Fig. 11. *Antrocephalus renalis* Waterst (♀).

spot of variable depth extends backwards. The hind femur shews two ventral lobes and a well developed inner basal tubercle.

*A. renalis* may be compared with *A. pandens* Wlk. (*Chalcis pandens* Walker F. Ann. Mag. Nat. Hist. Vol. VI, p. 357, 1860, Ceylon) and *A. mahensis* Masi (Novitat. Zoolog. Vol. XXIV, p. 133, figs. 10-11, May 1917). In the former species the legs, tegulæ, and antennæ (except the funicle basally and apically) are umber brown, the funicle, the scape,

(more or less), the hind coxæ and femora (except at base and apex) are darker—sepia coloured. The wings more infumated generally and

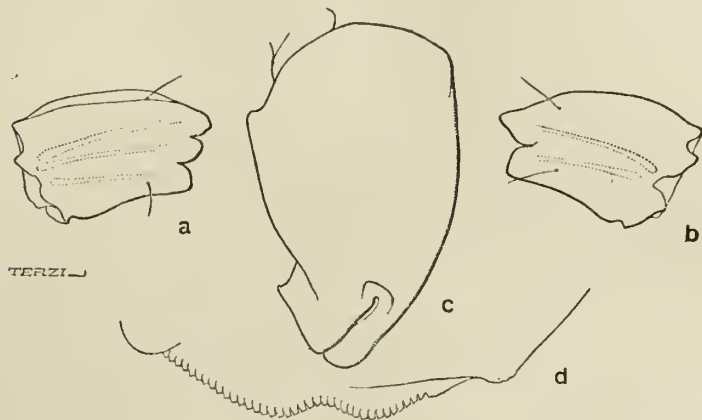


Fig. 12. *Antrocephalus renalis* Waterst (♀).

a, b. mandibles.

c. hind coxæ.

d. ventral edge of hind femur (inner aspect).

the spot extends to about  $\frac{1}{3}$  of the breadth of the wing. Post marginal shorter than marginal. Apart from colour *A. pandens* is slightly smaller, The sculpture of the propodeon (Fig. 13) differs only in comparative details, the general plan of the cells being the same in both species. In

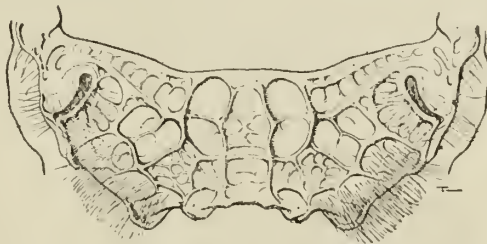


Fig. 13. *Antrocephalus renalis* Waterst (♀).

Propodeon.

*pandens* however the lateral post spiracular tooth is stouter. *A. mahensis* is much more distinct and may be told from either of the foregoing species by the very prominent distal denticulate lobe of the two on the ventral edge of the hind femur. The post marginal is nearly as long as the marginal and there are other colour differences for which the original description may be consulted.

Type ♀ in British Museum.

One of a series of 3 ♂♂, 10 ♀♀ ex pupa *Hypsipyla robusta* Moore "out of Toon" (*Cedrela Toona* Roxb.) Dehra Dun, United Provinces, May-June 1915 (C. F. C. Beeson). (April-May 1916, N. C. C.)

Besides the above *Antrocephalus* there are in the collection three other Haltichellid species represented by unique examples from unknown hosts.

### ***Antrocephalus humilis* sp. n.**

♀. Black, tegulæ and legs brown. Wings hyaline, with a brown-spot extending backwards from the marginal to about  $\frac{1}{4}$  of the breadth. Antennæ dark brown, the first two joints of the funicle, the third obscurely, and the club, paler.

Belongs to the section of *Antrocephalus* in which the scutellum is longitudinally sulcate and the hind femur bears a strong tooth or pointed tubercle on the inner aspect near the base.

Length 4.2 mm. alar expanse about  $6\frac{1}{2}$  mm.

Type ♀ in British Museum.

Under Bark. Dehra Dun, 7th January 1913. (A. D. Imms.)

Allied to *Antrocephalus Mityls* Wlk., (*Haltichella Mityls*, List Hymen. Brit. Mus., I, p. 84, 1846, Africa) and *Antrocephalus simplex* Wlk. (*Haltichella simplex*, Trans. Ent. Soc. Lond., p. 366. 1862, Africa), to which it is more nearly related than to *A. fabricator* Wlk., (l.c., p. 365) with which Walker compares his *simplex*. From *A. Mityls* the Indian form differs in its entirely dark abdomen, paler hind femora and darker funicle, while structurally the most salient contrast is in the lobing of the hind femur. In *humilis* these denticulate swellings are nearly equal in eminence and breadth (length) while in the others the more distal lobe is much the larger and more prominent.

### ***Antrocephalus phaeospilus* sp. n.**

♀. Black, shining. Tegulæ and legs except the fore coxæ brown. Wings nearly hyaline with a light brown spot on and behind the marginal to about  $\frac{1}{4}$  of the width. The antennæ are dark sepia coloured, only the pedicel with the first and second funicular joints brown.

Scutellum without furrow though posteriorly its apex is slightly bilobed. The emargination of the plate is slight.

The general thoracic punctuation is umbilicate and somewhat sparse (the punctures in many places separated by a diameter) with smooth interspaces.

No inner femoral tooth or tubercle.

Length barely 5 mm. Alar expanse, over 7 mm.

Type ♀ in British Museum.

Bhim Tal, Kumaon, United Provinces, 10th May 1912.

Closest to *Antrocephalus dividens* Wlk., (*Chaleis dividens* Walker Ann. Mag. Nat. Hist., Vol. 6, p. 357 ♀ 1860, Ceylon) in which however, the wings are generally infumated without any more localised spot; the hind tarsi are much infuscated, especially dorsally, and the hind tibiae streaked with blackish brown along the outer ventral edge from base to  $\frac{3}{4}$ . The antennae are nearly entirely blackish except on the pedicel and first funicular ventrally. The Ceylonese insect is also a larger, more robust species.

#### Genus HALTICHELLA.

##### **Haltichella macrocerus** sp. n.

♂. Antennae (excluding pedicel) body, all coxae, hind femora and tibia (except obscurely at apex) black. Fore and mid legs, hind trochanters with tarsi, and tegulae obscure umber brown. Wings tinted, the infumation darkest behind the marginal veins and tending to form a transverse band there; a second more obscure broad transverse cloud between the end of the neuration and the tip of the wing. Head and thoracic notum closely set with umbilicate punctures the interspaces dull. Scutellar processes long and deeply divided. Mesepisternite with about 20 deep punctures. Mesepimeron with about 14 ribs or ridges. Cells of propodeon deep and distinct.

Wings, post-marginal and marginal veins well developed, subequal. Hind femora beneath without well developed lobes or eminences.

Abdomen, 1st visible tergite occupying about  $\frac{3}{5}$  of the length, two short ridges basally behind the insertion into the propodeon. Surface perfectly smooth and shining even apically.

Length 5 mm. alar expanse  $9\frac{1}{2}$  mm.

Type ♂ in British Museum.

Bhim Tal, Kumaon, United Provinces, 15th June 1912.

This is an eastern representative of *H. armata* Panz., (*Cynips armata* Panzer Fauna Ins. Germ., Vol. VII, p. 94, t. 9, 1801) a widely ranging European species.



In *H. armata* however the anterior legs ( $\delta$ ) appear to be more or less infuscated and two males examined from France and England respectively are smaller and duller than the Himalayan form. In particular the first tergite apically is slightly punctate.

#### Family PERILAMPIDÆ.

Possibly the most interesting part of the collection consists of 2 series of 2 very well marked species of Perilampids, representing a genus which appears to be unnamed. Amongst described Perilampids I have found nothing suggesting either of these species—both parasitic on Platypodid (Coleoptera) species, but on going over the British Museum collection I have found, amongst the Cameron types, a form from Borneo, undoubtedly congeneric with the Indian species. This species Cameron placed in the genus *Philomedes* (Deutsch. Ent. Zeits. 1909, p. 205) but his account is defective besides being inaccurate in the description of the mandibles. Cameron's specimens, which had evidently been subjected at some time to damp, were so overgrown with a fungus mycelium, that in a preliminary examination the sexes could not be determined and the individual selected for dissection and mounting proved to be a male. As however the sexes in the genus appear to be extremely alike this fact does not invalidate the comparative value of fig. 17. The condition of the ovipositor in the group is remarkable. Its piercing powers must be slight and notes on the method of egg laying would be of interest.

#### MONACON gen. n.

♂ ♀. Head. Antennæ 13 or 14 jointed, if the minute generally separate apical segment of the club be reckoned as a joint. Scape slender, a little dorsoventrally flattened apically. Pedicel short, globose. Ring joint narrow with one whorl of short bristles; funicle thick, with transverse joints, broader distally than the 1st joint, and tapering into the apically pointed club. Mandibles, (figs. 16, *a*, *c*.) right with three long acute teeth, the median shortest. Left with two teeth. Labrum (fig. 16, *b*.) with margin deeply cleft into processes bearing flat bristles. Palpi with long slender joints. Facial impression V-shaped, deep, sharply sunk, with or without bordering carinæ. Frons with a distinct anteroventrally directed horn (figs. 14, 15, 17) or process. Wings. Submarginal long, marginal and radius moderate, postmarginal not longer than radius, submarginal cell rather broad, completely covered with bristles. Discal bristles evenly distributed, no isoclinal rows. Legs



slender, spur of fore tibia distinctly preapical. 2nd spur of hind tibia thick, short, and very divergent. 1st tarsal joint of mid legs over two times as long as the 2nd joint. Abdomen; shortly petiolate, 1st visible tergite smooth with a deep parabolic posteromedian emargination. On each side this tergite bears a row of small hyaline chitinous bosses set close to one another. 2nd tergite anteromedianly produced to fit the emargination of the 1st tergite practically fused with former to some distance, the median edges being continuous. Towards the sides the 1st tergite slightly overlaps the second.

♀. Ovipositor weak and flattened both median and side pieces with short bristles at and near their apices.

***Monacon productum* sp. n. (Fig. 14).**

♀. Black, with occasional blue-black submetallic lustre on head and thorax. Antennæ blackish brown. Wings clear, faintly brown tinted. Coxæ black, femora blackish brown, the rest of the legs paler. Head

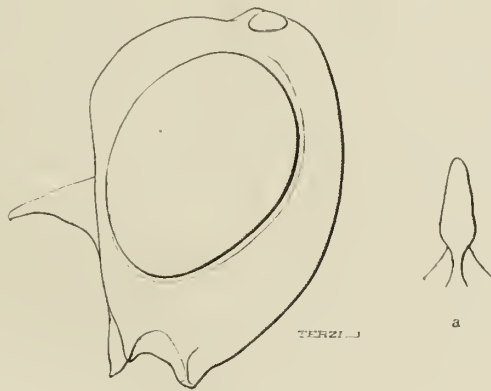


Fig. 14. *Monacon productum* Waterst (♀).

Head (profile) and (a) frontal process from above.

much broader than deep (3 : 2) when viewed from in front. Eyes separated by three-fifths of the breadth and barely two-thirds as deep as the head.

Toruli small, nearly circular, separated by less than the diameter of either and set in the middle of the face, which is deeply excavated, immediately above the stout process. The latter more slender and a little decurved distally (fig. 14). The deep facial hollow divides and shallows out on each side of the process. Clypeal area projecting downwards, the edge raised in two equal flat lobes meeting at a wide angle. On each side of the clypeal projection is a short upwardly recurved sulcus which is deep at the upper end. General surface dull shining with raised pattern faint and striate on occiput, more distinct but irregular on vertex and face, fine and more regular on malar space where the surface is dullest and there is a very indistinct keel. The head is set with whitish hairs which are most numerous on face and between the flange of the facial impression and the eye. Antennæ, length .98 mm., scape (13 : 2) sides subparallel, widest near the base. Pedicel (7 : 5) a little over  $\frac{1}{4}$  of the scape ; funicular joints equal from 2 onwards, transverse, the first joint (5 : 6) narrower than the others (5 : 7). The pedicel, ring-joint and first four funicular joints are together just longer than the scape. Club not half the scale (6 : 13) cone-shaped, on the base as wide as the 1st funicular, segmented in ratio 6 : 7 : 5 : 2. In same proportion the greatest width is 10. Sensoria, numerous, elongate, approximately as follows : 1st funicular and 2nd of club 8-10, 3rd of club, 4, the others about 12.

Mouth Parts ; labrum with about 12 long flat setigerous processes, 6-7 on each side of a deep marginal cleft. Epipharynx trapezoidal ; and just covered by the labrum, whose flat bristles however extend beyond. Mandibles yellowish brown, dark at base and on teeth, rather stout. About 12 bristles along the ventral edge and as many more evenly distributed on the outer surface. Both mandibles are curved, concave on the inner side, convex outside. The right distinctly narrowed just beyond the basal articulation and expanded apically. The teeth triangular, well developed. Trophi : the extreme elongation of these parts may be gathered from the fact that, when extended fully, a line from the base of the cardo to the apices of the maxillary palpi is over  $\frac{5}{8}$  the length of the antenna. Cardo narrow, longer than the stipes and equal to the mentum and galea. Maxillary palpi more than twice (25 : 11) as long as the labial, and segmented in ratio 6 : 5 : 4 : 10, the breadth of the 1st joint in same scale 2. The second a trifle broader ; 3 and 4 narrower, the 4th near the tip  $\frac{7}{10}$  of the breadth of the basal joint. Labial palpus 4 : 2 : 5. The stipes bears numerous bristles more closely set posteriorly, mentum with about 14 bristles. All the joints of the palpi bear a few short stiff bristles and there is in each case one longer terminal bristle, in the maxillary palpus  $\frac{1}{2}$ , in the labial well over  $\frac{1}{2}$ , as long as the supporting joint.

Thorax. Pronotum narrow collar-like sharply margined. Mesonotum broadest anteriorly across the extremities of the parapsidal furrows, scutellum longer than mid lobe and acuminate, posteriorly overhanging the metanotum. All the notal surfaces with deep umbilicate punctures regularly and closely set. Sides of scutellum smooth. Metanotum with 7-9 punctures on each side and smooth posteromedianly. Propodeon, descending with distinct median keel from which 3-4 very short branches come off without forming any major cells. Surface round the median keel raised reticulate. Spiracle reniform, placed outside a short keel from the anterior edge which can be traced backwards to above the insertion of the coxæ. Inside this keel there are posteriorly 1-2 large cells with raised edge. The space between the spiracle and the keels is smooth and sulciform. Below the spiracle and just before the suture with metapleuron the propodeal surface is smooth, but there is a row of punctures along the suture on both sides. Pleura; at the sides on its descending portions, the pronotum is covered with deep umbilicate punctures, which occur also round the inner margins of the prepectus. There are besides one or two more punctures on the upper half of this sclerite which is ventrally smooth and shining. A smooth spot at the sides of axillæ. Mesopleura smooth, a row of punctures round the edges of the episternum, none round the epimeron which however bears 3-4 punctures in a transverse row. The triangular portion of the sternum proper visible in profile is smooth superiorly but inferiorly bears 16-18 punctures. Metapleuron smooth except for one or two punctures around the edge. The mesosternum has a well defined median keel, otherwise smooth, though a little rough and punctured posteriorly.

Wings. Forewings (7 : 3); length 2.1 mm., breadth .9 mm. Submarginal : marginal : radius : postmarginal 9 : 3 : 1 : 1. The submarginal cell is long. To the uprise the submarginal vein bears 18-20 bristles, near the margin the radius bears 1-2 bristles and there are 4-5 others *placed at the sides*. Hindwings length 1.4 mm., breadth .45. Submarginal cell .9 mm. long, open to the hooks. Discal ciliation to well beyond half (nearly to the hooks) sparse, very minute, colourless, and nearly absent from the upper surface so that with a low power the wing appears transparent and bare; apically like that of the forewing.

Legs. Tibiæ; elongate, in forelegs 6-7 times, in mid and hind pairs 8 times, as long as broad; to the apex of the tibia unless otherwise stated, evenly clothed with rather long soft bristles. Forelegs, femur narrowly bare anteromedianly; tibia, comb, 4 spines between the spur and ventral apical angle, posteriorly 3 spines in transverse row at apex, 1st tarsal joint comb, about 18 fine spines continued to the apex, 4-5

much stronger. Midlegs, femur more extensively bare anteriorly. Anteroventrally near the apex 2-3 bristles spinose, and posteroventrally 3 in a transverse row; spur less than half the 1st tarsal joint, which bears ventrally about 10 spinose bristles. On the posterior aspect of the same joint 5-6 of the lower lateral bristles are spine-like. Hind legs; femur, posterior aspect sparsely set with bristles of which about half dozen are much longer forming an irregular median row. Tibia (from half onwards), the lowermost rows (1-3) of bristles are stronger and wider apart and there are 6-7 stouter, spinose, across the apex. Posteriorly the normal comb consists of 9-10 bristles.

Abdomen dorsally and posteriorly swollen, but not broad, ovipositor invisible from above. 1st tergite at its shortest and 2nd at its longest equal; together occupying more than half the visible surface. 3-6 diminishing in length, the 3rd half as long as the 2nd. The 1st tergite is smooth with some bristles mainly in front of the lateral chitinous swellings. From the middle of tergite 2 onwards the surface becomes duller and raised reticulate with 3-4 posterior rows of bristles. The spiracle is very small, circular, and heavily chitinized. The setigerous process (bearing 5 bristles) is closely surrounded superiorly by a row of minute stiff bristles and there is a patch of longer bristles below. Between the processes the surface bears numerous short stiff bristles. The short free portion of the sheath (not articulated), is  $\frac{1}{6}$  of the base.

	1	2	3	4	5
I . . . . .	65	27	25	20	50
II . . . . .	100	32	24	20	45
III . . . . .	90	35	26	25	50

Length about 3.2 mm. Alar expanse about 5.2 mm.

The ♂ which otherwise closely resembles the ♀ differs conspicuously in the sculpture of the propodeon which descends less abruptly than in the ♀ and has the dorsal surface completely occupied by large deeply hollowed cells placed symmetrically about the mid line.

Length about 3 mm. Alar expanse about 5 mm.

Type ♀ in British Museum bred from *Diapus furtivus* Samps., (Platypodidae) which attacks "Sal" *Shorea robusta*. One of a series of 18♂♂, 7♀♀, Apalchand Range, Jalpaiguri, Duars, Bengal. Emerged Dehra Dun, August-September 1913. [Rajabhatkhawa, Buxa, Bengal, 9th November 1914 with *D. furtivus* ex Sal. C. F. C. Beeson].



***Monacon abruptum* sp. n. (Figs. 15, 16).**

♀. Similar to *M. productum* and with even darker femora. A smaller species. Head (Fig. 15); facial excavation very wide and in profile not margined. Sub-torular process (Fig. 15, *a*) short truncate and a little

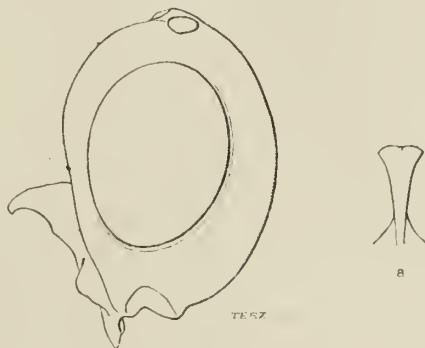


Fig. 15. *Monacon abruptum* Waterst (♀).

Head, profile and (*a*) frontal process from above.

concave apically, flanked below on each side by a small prominence above the depression at the upper end of the clypeal sulci. Antenna length .77 mm, scape (5 : 1) a little shorter than in *M. productum*, pedicel more globose (4 : 3), club longer,  $\frac{3}{5}$  of the scape. The sensoria of the funicular joints are more numerous, up to 14 or 15. Mouth Parts, labrum with 8 marginal processes and not deeply cleft medianly. Maxillary palpus (30 : 21 : 18 : 40.) with joints 2-4 relatively shorter than in *M. productum*. Stipes with fewer bristles on distal  $\frac{2}{3}$ .

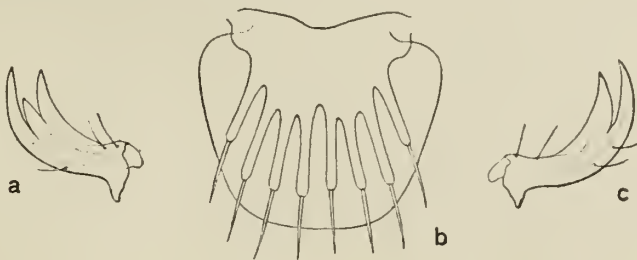


Fig. 16. *Monacon abruptum* Waterst (♀).

*a, c.* mandibles.

*b.* labrum—epipharynx.



Thorax punctuation coarser than in *M. productum*. On the ascending portion of the mesosternum, seen in profile, 9-10 punctures. Episternite nearly all punctured, while coarser punctures flank the median sternal carina. Wings. Forewings, length 1.7 mm., breadth .75 mm. The veins are in the same proportion as in *M. productum*, but the radius is a little longer and the post marginal shorter. The submarginal bears 2-3 bristles fewer, while the radius has about 8 bristles (3-4 : 3-4) placed almost entirely at the side as in *M. productum*.

Hindwings, length 1.15 mm., breadth .4 mm.

Propodeon medianly swollen, the median keel extending forward only to the highest point of the swelling and there dividing to enclose a large pentagonal cell which abuts anteriorly on the metanotum. Up to the point of forking there are, on each side, 3 deeply sculptured cells and the surface is nowhere flattened as in *M. productum*.

Length 2.6 mm. Alar expanse over 4 mm.

Type ♀ in British Museum bred from *Platypus uncinatus* Blandf. (Platypodidæ), which attacks "Sundri" *Heritiera Fomes* Buch. One of a series of 10 ♀ from Tambulbania, Sunderbans, Bengal. Emerged at Dehra Dun, March-April 1913. C.F.C.B.

Some additional notes are here given on *Monacon spinifrons* Cam. For head see fig. 17. Mouth Parts; labrum, 14 processes; rather deeply cleft in the middle. Cardo longer than either stipes or galea. Mentum with about 30 bristles. Proportions of maxillary palpus practically as

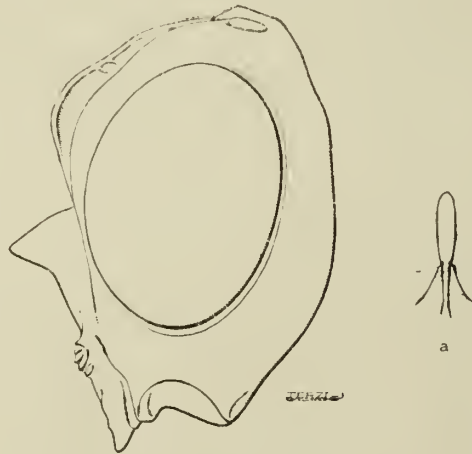


Fig. 17. *Monacon spinifrons* Cam (♂).

Head (profile) and (a) frontal process from above.

in *M. productum* but, in the labial palpus, the 3rd joint is longer. The proportions are 2 : 1 : 3.

Wings. Length 2.2 mm., breadth 1 mm. As in the other species the submarginal is about thrice the marginal but the radius and postmarginal (10 : 9) are more developed, the former being nearly  $\frac{1}{2}$  the marginal and not a little over  $\frac{1}{3}$ . There are 9-10 bristles on the radius. Hindwings, length 1.55 mm., breadth .55 mm. The upper surface of the basal half is not so bare as in other species there being numerous scattered short bristles all over.

Legs. Hind tibiae with apical comb of 12 spines posteriorly and about 6 in a transverse row anteriorly. In the mid tarsus the proportions are 90, 30, 25, 20, 40 (without claw). In the hind tarsus, joints 2-4 are absolutely and relatively the same as in the mid legs, 1 and 5 each a little longer. The hind tarsus is however more robust.

### Family MISCOGASTERIDÆ.

#### OEDAULE gen. n.

♂. Head broad from in front, in profile narrow. Occiput and genæ posteriorly rounded, malar keel fine but distinct, eyes widely apart, toruli about the middle of the face, antennal fossæ confluent, deep above the toruli and reaching upwards to the anterior ocellus. Ocellar triangle flattened, the ocelli nearly in a straight line, 2 distinct approximated teeth on the clypeal edge medianly. Antennæ cylindrical, narrow,? with two ring joints, mandibles short, 4-dentate, the upper pair of teeth on the left side shallowly separated. Thorax stout, pronotum margined anteriorly, and flattened at the sides the flattening continued backwards on the meso- and metapleura, *i.e.* all femoral impressions slight. Parapsidal furrows fine posteriorly. Propodeon bluntly produced behind, with lateral, but without median carinae. Spiracle moderate, subreniform. Wings with large hairy subcostal cell, veins strongly developed, postmarginal exceeding the radius, stigma large.

Legs, hind femora slightly thickened. Abdomen very shortly petiolate.

**Oedaule stringifrons** sp. n. (Fig. 18).

Head and thorax dark aeneous with greenish or coppery metallic reflections the green prevailing above and round the clypeus and along the orbits as well as on the coxæ which are very dark. Abdomen blackish brown faintly metallic posteriorly with a large clear yellow spot basally extending backwards to nearly one half and at its maximum occupying three-fourths of the breadth. Wings clear but slightly yellow tinted with well defined veins which are darker on (and narrowly round) the stigma and on and below the junction of the submarginal with the faintly indicated vena spuria. In the antennæ the funicle (and club ?) are blackish brown with paler scape, pedicel (darker above) and ring joints. Mandibles with dark teeth but paler basally, tegulæ pale brown. In the mid and hind legs the trochanters, femora, and tibiæ are clear brownish the tibiæ being paler on the apical  $\frac{1}{5}$ .

Head, from in front, broader than deep, (19:16). The eye is half as deep as the head and the malar space  $\frac{3}{8}$ . Frons wide occupying near the vertex  $\frac{5}{8}$ , and towards the base line of the eye,  $\frac{3}{4}$ , of the breadth of the head. Mouth opening wide. Pattern everywhere strongly raised; on the genæ behind the thin impressed malar keel, round the orbits, behind the antennæ, and on the vertex, it is fine and regular, coarser and irregular (with incomplete cells) on the face. Below the level of the toruli the entire surface is furrowed coarsely in the middle and more finely towards the sides, the furrows converging towards the clypeal edge.

Thorax. The entire dorsal surface regularly raised reticulate, the pattern fine but a little coarser than on the vertex. Where the scutellum begins its descent a row of slightly larger cells forms an indistinct and faint transverse line. Metanotum; mid area with irregular punctures where overhung by the scutellum; side pieces smoother with a few shallow indistinct punctures along the anterior edge on the inner half. The thoracic pleura are similar in sculpture to the notum. Metapleuron divided into two nearly equal areas by a row of larger punctures (3-4) which does not quite reach the suture between the epimeron and the metapleuron.

Propodeon; general surface texture like that of thorax but a little finer. Mid areas with a shallow triangular depression anteriorly at the base of each keel. These run backwards to end indefinitely at the base of the short petiolar neck, the surface being excavated and smoother inside the keels just before the neck. Anteriorly (basally) the lateral keels are broad enough to shew a distinct raised pattern but posteriorly they thin out to a fine edge. Behind the spiracle the surface is deeply excavated and there is a well defined pre-spiracular sulcus widening

outwards along the outer anterior edge of the segment. Numerous short white hairs stand outside the spiraeæ above the metapleuron.

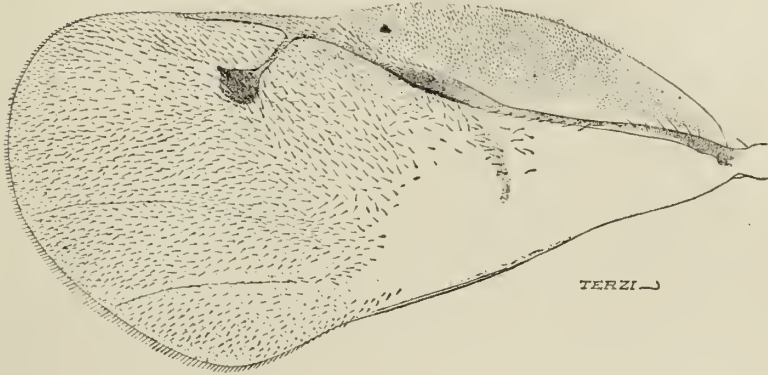


Fig. 18. *Oedaule stringifrons* Waterst (♂). Wing.

Wings. Forewings  $2\frac{1}{5}$  times as long as broad, length 3.3 mm., breadth 1.5 mm. To the eye very broad, widest beyond  $\frac{3}{4}$  from the base. The hind margin shortly concave near the base where the wing contracts abruptly. Neuration peculiar. The submarginal and marginal (up to the costal abscissa of the latter) is 1.75 mm. long, shewing (a) a more slender basal portion 1 mm. (entirely submarginal), (b) the swollen splice of marginal-submarginal .5 mm., and (c) a short piece of the marginal .25 mm. For a short distance the marginal lies nearly on the costa towards which it thins off. The costal abscissa (.2 mm.) is no longer than the thin stalk of the radius and shorter than the postmarginal. Radius and postmarginal equal--the club large and quadrate, the clear cells projecting finger-like at the anterior apical angle. Submarginal cell broad (.4 mm.) spindle-shaped, the costa bulging anteriorly and the neuration curving back posteriorly, evenly and densely set below with numerous minute bristles, bare superiorly. About 24 short, stiff, single bristles on the submarginal to the end of the distal swelling beyond which, and along the costa, the marginal bears many short black bristles 3-4 deep. There is a very narrow costal edging in front of the abscissa of the marginal, and only the postmarginal is truly on the costa. The stalk of the radius bears 14-16 bristles. The large knob about 50. Behind the submarginal the base of the wing is broadly bare with only a few bristles set in a curve at the foot of the swelling. From the apex of the latter the discal ciliation is regular, sparser below the radial knob, and from the latter towards the apex



parallel with the costa. On the under surface, behind the postmarginal, the minute bristles are numerous but not so closely placed as in the submarginal cell. There are two parallel isolated isoclinal rows of bristles, one (meeting the apical edge at  $\frac{1}{3}$ ) rises below the knob, the second (at  $\frac{3}{4}$ ) much longer, rising above the retinacular edge. The marginal fringe is extremely short and sparse, especially at the apex. Hindwings, length 2.3 mm., breadth .8 mm. In its basal half the submarginal vein is broad and extends to the costa, fringed with about 20 soft bristles while on the distal half it is attenuated. Marginal vein giving rise to a little splint or recurved vena spuria with 2 bristles at its base. Numerous short bristles on apical half of the submarginal cell, 20 minute bristles at the hooks. Beyond the neurulation is a short just post-costal apical row of isoclinal bristles. The basal emargination of the hind edge, deeper than in the forewings, bears a row of converging soft bristles. The wing is at its broadest just beyond  $\frac{1}{3}$  from the radix, which, as in the forewings contracts rather suddenly.

Abdomen. Shorter than thorax (2 : 3), smooth, shining, with faint transverse pattern indicated chiefly posteriorly. 1st segment occupying about  $\frac{1}{3}$ .

Length 4.5 mm. Alar expanse 8.2 mm.

Type ♂ in British Museum. Dehra Dun 5th March 1913. From "seeds of *Albizzia Lebbeck*" sent by R. S. T. ex *Caryoborus gonagra* Fab. (Bruchidae).

### Family PTEROMALIDÆ.

#### Genus ROPTROCERUS Ratz.

*Roptrocerus* Ratzeburg Ichneum. d. Forstins. Vol. II, p. 209, t. 3, f. 2 (1848).

The species described below is evidently congeneric with *Roptrocerus* (*Amblymerus*) *mirus*, Wlk., (1834) with which a comparison has been made. In several details however the published descriptions of the genus do not apply well to the Indian species. In it the antennæ are cylindrical only a little enlarged in the short club which is peculiar in showing a small apical cap separated from the 3rd segment by a suture. This is probably a terminal sense organ and not a separate segment. There are two actual, as well as an apparent third, ring joints—the third being the much shortened transverse first funicular. The first tarsal joint in all the legs is elongate. The propodeon (besides the characters noted elsewhere) shows a deep sulcus along the anterior margin on the outer half immediately behind the metathorax. This sulcus consists



of confluent punctures or at any rate is crossed by 5 or 6 very short rugæ. (A similar shorter sulcus exists in *R. mirus*). At the inner end of the sulcus the surface of the propodeon is distinctly hollowed anteriorly, sloping upwards again towards the mid keel. The spiracular area is thus somewhat elevated but the surface rises slightly beyond the spiracle itself around which is a narrow smooth gleaming very shallow sulcus.

***Roptrocerus sulcatus* sp. n.**

♀. Dark aeneous, green metallic, the coxæ, particularly the hind pair, blue. Wings hyaline. Base of abdomen (at sides only) paler. Antennæ dark except for the slightly paler scape, ovipositor barely lighter than the body; legs, femora especially the hind pair smoky, trochanters, tibiæ and tarsi paler. A moderate sized species distinguished by the structure of the propodeon.

Head broader than deep (9 : 8), from in front broadly oval; orbits not greatly divergent inferiorly. At their nearest the eyes are a little over  $3\frac{1}{2}$  diameters apart, while at the base line  $4\frac{1}{4}$ . Toruli circular, simple separated by the diameter of either and distant from the orbits and the clypeal edge respectively 3 and 4 diameters. They lie well above the base line of the eyes and a line across their upper edges bisects one midway between the anterior ocellus and the middle of the clypeal edge. Clypeus narrow oblong, slightly salient its edge nearly straight and separated on each side by a shallow dimple from the rest of the mouth edge. The eye is half the depth of the head and the malar space one quarter. Reticulation everywhere fine and a little raised, coarsest on the vertex, finest above the toruli and generally regular, but below the toruli more transversely drawn out and scaly. Only the actual clypeal edge smooth. All over the frons shows numerous extremely minute irregularly disposed fine bristles and there are about half a dozen stronger along each orbit. On the clypeus and between the toruli and the genal keel are numerous clear setigerous pits penetrating the chitin. Above the mouth and clypeal edges the majority of these pits emit short hyaline quickly tapered bristles, but on the mouth edge the bristles become longer. The clypeus bears 24-26 such pits, 4 of which (2 in the centre and 2 near the edge) have long bristles; from below the clypeus rises a bristle at each angle.

Antennæ (Fig. 19, *b*) length 1.32 mm.; Scape (not quite 5 : 1), pedicel (2 : 1) about  $\frac{1}{3}$  of the scape. Ring joints, together  $\frac{4}{5}$  as long as the pedicel. The second a little broader than the first and half as broad as the third (modified first funicular). First normal funicular joint longer (11) than any of the four succeeding ones (9) which are equal, joints 1-3 with a breadth of 8, 4-5 breadth of 9. Club in the ratio 7 : 4 : 3 : 1, with transverse sutures 10 : 7 : 3. Scape and pedicel rough, raised reticulate :

pattern moderately fine, regular; bristles on all surfaces short, rather stout, evenly set; the ring joints bearing 1, 2, and 3 transverse rows respectively. Sensoria elongate, numerous, 2 rows (containing 22-26 sensoria) on all normal funicular joints and on the 1st of the club, of which the 2nd and 3rd bear only 1 row (16 and 7 or 8 respectively). Mouth parts. Labrum (fig. 19, c) oblong (8 : 5) with 4 long stiff bristles (2, 2) of which

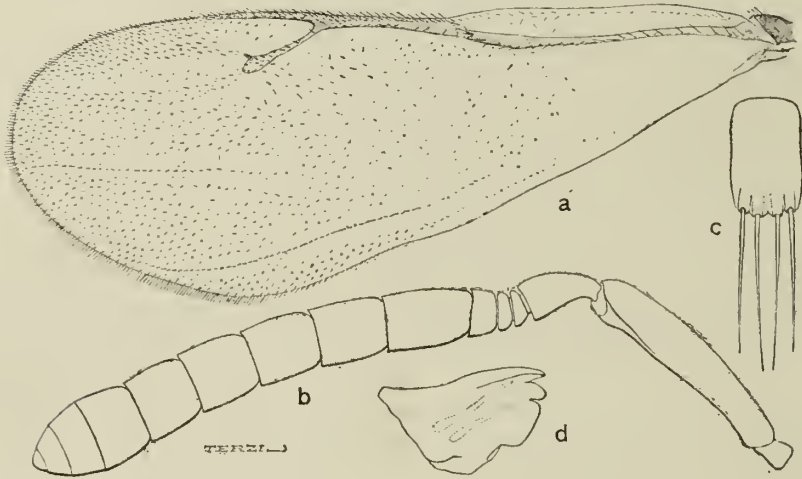


Fig. 19. *Roptrocerus sulcatus* Waterst (♀).

- a. forewing.
- b. antennae.
- c. labrum
- d. mandible.

the outer pair are as long as the sclerite itself and the inner  $\frac{1}{4}$  longer. Maxillary palpus 3, 4, 3, 6; of the bristles on the galea 7-8 on the distal edge are stout. Mandibles (Fig. 19, b) moderately long, the lower basal angle a little produced, tridentate, the upper tooth broad, thin. Bristles nearly all on the lower outer aspect, there being about 6 moderate sized ones before the first tooth and a dozen minute along and about the ventral edge. The surfaces of the mandibles are smooth except for the basal ventral angle, which is curiously raised reticulate.

Thorax. Prothorax: posterior row of bristles short 16-18 between the spiracles where there is an incrassation of the chitin. On the prosternum are 5-7 bristles posteriorly on each side of the mid line. Mesothorax elongate, the posterior ends of the parapsidal furrows much further apart (7 : 5) than the inner anterior angles of the axillæ. From the posterior edge of the pronotum to the suture the mesonotum is as long as the scutellum. From above, the side lobes bulge considerably,

forming a biconvex angle with the mid lobe. The pattern anteriorly transverse to nearly the level of the side lobes, elsewhere regular and raised. Chiefly on the side lobes and before the furrows on each side occur a few scattered very minute bristles. Scutellum (10 : 9) broadest preapically and overhanging the post-scutellum. The basal abscissa is just one half the length. Pattern like the mesonotum, finer behind the suture and largest and coarsest on the broad edge above the post-scutellum; narrowly bare medianly, with about 15 : 15 bristles and 2 small sensory pustules very wide apart near the apex. The last 3 bristles, on the overhanging portion on each side are stronger than the others. Axillæ with 18-20 minute bristles chiefly near the suture. Sternopleura, mesosternum entirely finely raised reticulate, the pleural portion concave and bare, the sternal quadrate area with a number of minute bristles laterally and posteriorly, but mainly bare. Episternite anteriorly rough, smooth behind. Upper portion of the epimeron smooth but reticulate lower with a coarser distinctly raised pattern. The prepectus is long and narrow but the actually exposed portion (a little over half the depth of the sclerite) is in the form of a rough isosceles triangle. Metanotum : (a) post-scutellum broad, band like sub-pentagonal, with little longitudinal rugæ on its surface (b) area with raised transverse reticulation bounded posteriorly by a close set row of minute punctures before the propodeon. Side pieces anteriorly raised reticulate, posteriorly smooth with 5-6 longitudinal ridges. Propodeon on each side of the short median keel are two descending rough triangular areas; spiracles oval, flattened on the inner side, rims distinct. Round the spiracles on outer aspect is a flat gleaming sulcus and the surface beyond is reticulate or striate, but not much raised. The sulci, not connected with the spiracles by any branch, are crossed by one or two small longitudinal rugæ. Below the spiracles the metapleura bear numerous short soft bristles. Behind the spiracles the surface is a little swollen. The petiolar emargination is slight, gently concave. From above, the posterolateral angles are distinct but not produced.

Wings. Forewings (fig. 19, a) (8 : 3) length 2.8 mm, breadth 1.05 mm. Submarginal : marginal : radius : postmarginal 22 : 11 : 6 : 8. There are 4 clear pustules on the junction of submarginal and marginal near the apex of the submarginal cell. 22-24 bristles on the submarginal vein and about 28 short major bristles overlapping on the marginal and postmarginal, the latter continuing a short distance beyond the last stronger bristle. The radius bears about 18 bristles. In the apical cell there is a complete submarginal row of bristles (26-30) and a second row of slightly longer bristles (6-8) accompanies the first to rather less than half from the apex. Upper surface; nowhere except at the end of the

radius does the discal ciliation come close to the vein. To beyond the upturn of the submarginal the basal triangle is bare, so also is the angle between the radius and the postmarginal. A broad bare track extends below the marginal. From the end of the radius a broad nearly bare line extends almost to the apex. Beginning behind half and extending parallel to the costa an isolated row of isoclinal bristles extends to below the radius. Another row runs some distance from the hind margin and parallel with the latter beginning below the origin of the marginal and bending round to meet the apical edge in front of the posterior angle. There is also a short submarginal row along the retinaculum. Hind-wings over thrice as long as broad, length 2.1 mm., breadth .6 mm., submarginal : marginal 4 : 3, 8-10 minute bristles behind the hooks, and 2 stronger before the upward bend of the vein, which emits a basally directed short chitinous vena spuria.

Legs ; from coxa to end of tibia all the legs shew a distinct pattern, that on the coxæ being coarse and much raised, at least externally. All the tibiæ are closely set anteriorly and more sparsely posteriorly, with equal short bristles, but on the hind legs (posterior aspect) the bristles sub-dorsally and subventrally (2-3 deep) are stouter and longer. The first joint of the tarsus is elongate (see table) while 1-4 bear on both edges numerous equal short spinose bristles, 1-2 pairs at the tip being heavier. The fifth joint is entirely covered with minute weak bristles. Forelegs tibial spur pre-apical, anteriorly 5 spines in apical comb, opposite the spur, and another, no longer, isolated, at the apex ; posteriorly, before half way between the spur and the insertion of the tarsus, is a remarkable short stout spine, and 2 very short peg-like spines at apex. Comb of 1st tarsal joint (extending to apex ventrally), with about 40 closely set thin spines, Mid legs : anterior apical comb, irregular, 6-7 spines, spur  $\frac{2}{3}$  of the 1st tarsal joint. Hind legs : femur posteriorly a few subdorsal bristles towards the apex, an infra-median row of longer bristles (about 12) and some others very minute ventrally near base. Tibia ; the short spur (about  $\frac{1}{3}$  of the 1st tarsal joint in length) lies between two apical combs, of which the anterior contains 14 stouter, and the posterior 22-24 finer spines. *Though the spur is undoubtedly single the apex of the hind tibia requires careful examination.* On the sloped apical edge (anterior) of tarsal joints 1-3 there is a median short spine. Abdomen, only medianly (broadly) on the 1st tergite and (narrowly) on the second is the surface smooth. The pattern is transversely elongate and a little raised on the 6th. Spiracles minute, nearly circular, separated from the posterior edge of the tergite by 6 times their own diameter. The setigerous process on tergite 7 bears 5 short bristles. Free portion of the sheath  $\frac{2}{3}$  of the base.



Length about  $5\frac{1}{2}$  mm. of which the }  
 ovipositor is nearly  $1\frac{1}{2}$  mm. } Alar expanse over  $6\frac{1}{2}$  mm.

Proportion of Tarsal joints (excluding claw).

	1	2	3	4	5
I . . . . .	15	9	6	3	10
II . . . . .	17	12	6	5	10
III . . . . .	28	13	7	5	13

Type ♀ in British Museum.

One of the series ♂, 7 ♀♀, bred from pupal chambers of *Ips longifolia* Stebb., in galleries under bark of 'Chir' Pine (*Pinus longifolia*) Bhowali, Kumaon, United Provinces, 6,000 feet 21st June 1914, C. F. C. Beeson.

### Family EULOPHIDAE.

#### Genus TETRASTICHUS.

#### *Tetrastichus spirabilis* sp. n. (Figs. 20, 21, 22).

♀ Head wider than deep (6 : 5) ; eyes bare, rather small, nearly half the depth from vertex to mouth edge, and separated by four times the diameter of either (seen from in front) across the middle of the frons.

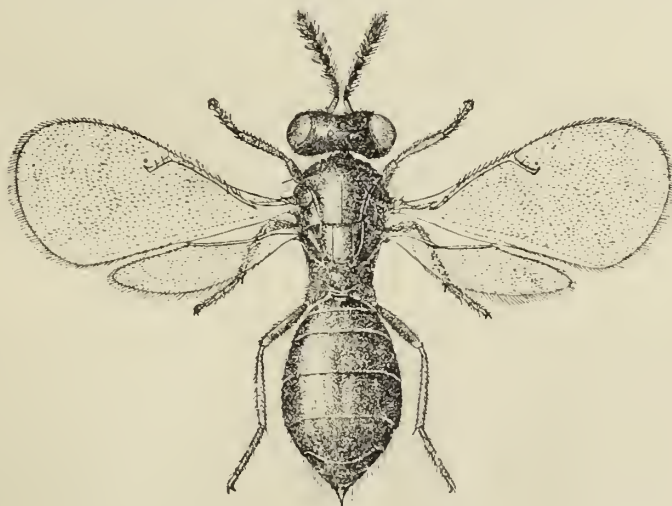


Fig. 20. *Tetrastichus spirabilis* Waterst. (♀)



Orbits not very divergent ventrally, a transverse line through the anterior ocellus being to the base line of the eyes in ratio 5 : 6. Malar space deep, in profile two-thirds of the eye, which the keel itself just equals. Clypeus narrowed, with a median notch and one at each angle where it meets the genæ. Antennæ set on the base line of the eyes, about one-third of the scrobes being below, the latter oval, inclining towards one another and hardly narrowed superiorly. Bristles on the face rather sparsely set, those at the orbits not more developed, 8-9 short bristles between the scrobes, one above each lateral notch longer.

Antenna : length,  $\cdot 75$  ; scape (19 : 5) not quite as long as the sum of the normal funicular joints and less than three times as long as the pedicee (19 : 7) pedicel (8 : 5) ring-joint compound, a large basal joint with stout stalk and a second consisting of at least two laminæ ; funicle with joints in ratio 7 : 7 : 6, breadth in same scale, 5, the second and third a little broader ; the club joints are 5 : 5 : 4 with a breadth of 7-8. The sensoria are numerous each joint of funicle and club bearing two rows, as follows 10 : 12 : 14 ; club 16 : 14 : 6. The sensoria of the posterior rows are



Fig. 21. *Tetrastichus spirabilis* Waterst.  
Mandible and radius.

short with long narrow processes, while those more distally situated are longer with short broad flanges.

Mouth parts : labrum trapezoidal, broadest anteriorly, with four long stoutish bristles, two more central and two at the sides, each of the latter pair extending to twice the breadth of the sclerite itself. Mandibles (Fig. 21) broad, basal edge only about one-eighth less than the length lowermost tooth short, the uppermost large and separated by a shallow

concavity from the median. Upper internal hollow or rib longer and slightly broader than the lower. First maxilla: stipes—in some specimens there are abnormally 2-3 lateral bristles; palpus, four bristles, one at a half and three (one short) at the apex; labial palpus about one-third of the maxillary.

Thorax. Pronotum: the ventral edge of the overlap is straight turning up at right angles to the distinct spiracular emargination. The posterior row consists of 10-11 bristles and there are about thirty others (15:15) of which the more anterior are minute, in front. Prosternum very broad (5:3), with narrow lateral angles. The pattern is everywhere distinct and coarsest on the lower overlaps. Mesonotum: the impressed lines on mid-lobe and scutellum distinct; the former bare medianly with 5-6 bristles along the inside of the parapsidal furrows; side lobes with seven bristles. The scutellum descends steeply posteriorly so that from above even the more anterior pair of bristles (*i.e.*, the first behind the suture) are placed well beyond one half. The pattern of the thoracic notum is fine, longitudinally drawn out everywhere and very definitely raised. Prepectus long, rather narrow and not contracted to a point,

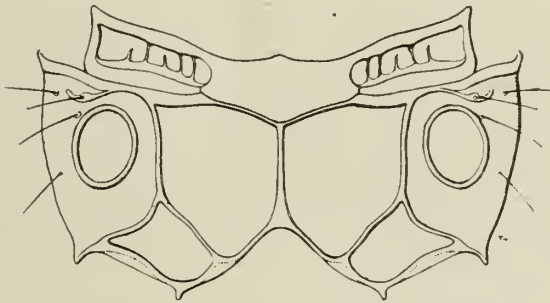


Fig. 22. *Tetrastichus spirabilis* Waterst.  
Propodeon.

reduced only to one half the width ventrally; with large coarse pattern on the upper two-thirds, smooth ventrally. Mesepisternite smooth, sternopleura with the same sculpture as the prepectus; sternite rough, the cells larger posteriorly, with four (2,2) short bristles posteromedianly; epimeron nearly smooth, the pattern fine not raised. Metathorax: the post-scutellum without median carina, surface reticulate but little

raised ; greatest width exceeding the length of the well-defined median carina of the propodeon. Dorsal surface of the latter without sculpture

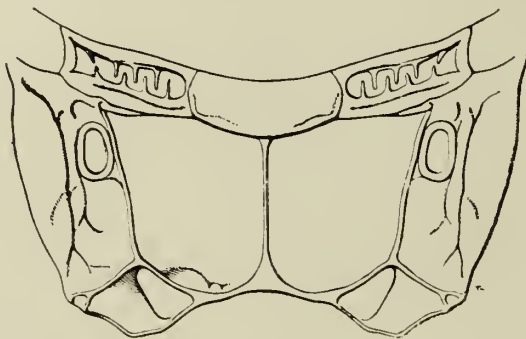


Fig. 23. *Tetrastichus tachos* Walk.  
Propodeon.

apart from a uniform much raised coarse reticulation. Both lateral and median carinae well developed, the former subparallel and dividing posteriorly into two branches of which the inwardly-directed one is longer and finer : these branches, together with the posterior margin of the propodeon enclose a quadrangular space whose diagonals do not intersect at right angles. The spiracle (Fig. 22) very large with a short sulcus, and extending backwards outside the lateral keel, beyond the fork, occupies nearly all the lateral surface of the propodeon above the metapleura.

Wings.—Forewings nearly two-and-half times as long as broad ; length 1.55 mm. ; breadth .65 mm. ; the submarginal is about one-fifth less than the marginal, and the latter is four times the radius (Fig. 21), which bears four bristles on the stalk. The submarginal bears near the base a single bristle, and there are 12-13 fringing bristles on the marginal ; along the submarginal, on the inferior surface, there are 8-9 bristles, and 3-4 more at the apex ; there are two bristles on the root of the marginal before the clear cells. Hindwings : length 1.2 mm. ; breadth .3 mm.

Legs.—The fore and hind coxae particularly the latter, are rough with numerous bristles, Fore legs : femur—anterior surface with about twelve short bristles in a subdorsal row, 9-10 longer on ventral edge, and posteriorly two rows of 6-7 each, one on the mid line the other above.

## Proportions of tarsal joints:—

—	1	2	3	4
I . . . . .	20	25	20	35
II . . . . .	32	30	25	35
III . . . . .	35	35	30	45

Abdomen: the sixth tergite has a posterior row of 16-17 short bristles, with one or two more *between*, and 2-3 *outside* the spiracles. Ovipositor as in all of this group stout; fore portion of the sheath two-fifths of the base.

Length about 2 mm.; alar expanse, nearly  $3\frac{3}{4}$  mm.

♂. Head very slightly broader than in the ♀; the three minute clypeal notches more distinct; face above the clypeus a little swollen. Antenna: length .88 mm.; scape (17:6) externally swollen, longer (21:8) in proportion to the pedicel than in the ♀; sense organ covering about three-fourths of the ventral surface, fringed with only three rather long bristles; funicle and club cylindrical, joints of the former in the ratio 32:38:42:40 and of the latter 30:26:27. In the same scale the breadth of the first two joints of the funicle is 24, and of the remaining joints (except the diminishing third of the club) 22.

Propodeon; spiracle relatively a little smaller, its posterior margin about the level of the forking of the lateral keel.

Wings; Forewings over twice as long as broad; length 1.25 mm.; breadth .6 mm. Hindwings, length 1 mm.; breadth .25 mm.

Abdomen; Posterior row of sixth tergite 12-13 bristles, with 1-2 outside, and 1-3 on the inside towards the middle, near the spiracle, between the styleta are six bristles (3, 3); there are also two outside, and two (1, 1) in front.

Length, nearly  $1\frac{1}{2}$  mm; alar expanse 3 mm.

Type ♂ in British Museum Collection, one of a series of both sexes; For. Zool. Coll. Dehra Dun, 21st August 1915. (C. F. C. Beeson).

Host: larvæ of *Hypsipyla robusta* Moore (Pyralidæ); "Flies out of Toon shoots."

Except in the propodeon *T. spirabilis* runs extremely close to *T. tachos* Wlk., 1839, ♂ (Britain). In the British species the antennæ are blackish brown, nowhere paler; head, thorax and abdomen black, with very dark blue metallic reflections. In some lights the head has faint greenish tints overspreading the blue which again on the disc of the abdomen passes into purplish. The abdomen is most shining; head and

thorax hardly duller; propodeon much duller generally, owing to the raising of the reticulation, but with scattered points of light from the bottom of the cells. Wings hyaline, veins decidedly brownish. Legs coxa and femora (except apex in hind legs, more broadly in mid and fore pairs) metallic blue black; apices and tibiæ brownish yellow; first two tarsal joints paler still; third a little darker; fourth brown.

In *T. spirabilis* the ♂ is duller than *tachos* and practically non-metallic; (this may be due partly to preservation in spirit) veins paler. Legs brownish black, non-metallic; hind femora concolorous; mid and fore femora narrowly and obscurely paler at the apex; hind tibiæ pale smoky; hind tarsi, fore and mid tibiæ and tarsi very pale, claws darker. In the ♀ the scape of the antennæ is pale; hind tibiæ paler than in the ♂, and the femora of a lighter brown. The ♀ of *tachos* is unknown.

Besides the colour differences the species may be separated by the propodeon (figs. 22, 23). In *tachos* the spiracle is small and the central keel longer than the middle of the post-scutellum, while the diameters of the area bounded by the forked extremities of the lateral keels intersect at right angles. In *tachos* also there are eight short bristles fringing the scapal sense organ, and the joint itself is narrower.



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Parts I—V**

By

**MADYAR GOPAL RAU**

and

**JOHN LIONEL SIMONSEN**

*Forest Research Institute, Dehra Dun.*



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# INDIAN FOREST RECORDS

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## Oils and fats from the Seeds of Indian Forest Trees, Parts I—V

BY

MADYAR GOPAL RAU AND JOHN LIONEL SIMONSEN.

### Introduction.

IN view of the ever increasing economic importance of oils and fats it has appeared to the authors desirable to commence a study of the properties of the various oils and fats obtainable from the Indian forests. In the following pages a preliminary account is given of the yields, chemical and physical properties of a number of new oils and fats.

It is obvious that for an oil to be of economic value, unless it should happen to possess some distinctive property, the source from which it is obtained must be available in quantity, convenient for transport and low in price, whilst the oil (or fat) content of the seed should be high. As the result of the investigations described below it would appear that the oil from *Calophyllum Wightianum* is likely to prove of economic importance, whilst the fat from *Garcinia Cambogia* is similar in properties to the so-called "Kokum" butter from *G. indica* and should be of equal value. In the cases of the other oils which were examined either the oil content was too low or the supply was limited.

The oils used for investigation were obtained from the seeds either by expression or solvent extraction or by a combination of the two processes. The methods adopted for the determination of the physical constants, and for the analysis of the oils were the standard ones in general use. The solid and liquid acids were separated, after hydrolysis of the oil, by means of their lead salts in the usual manner and the crude mixtures

of liquid and solid acids thus obtained were separated either by fractional distillation of the methyl esters or by fractional crystallisation of the salts. As has been found by other investigators the ester method proved to be very satisfactory especially in the case of the solid acids. The separation of the liquid fatty acids offered greater difficulty and the separation was most conveniently followed by determination of the iodine value.

The authors wish to take this opportunity of expressing their thanks to the various Forest Officers who have supplied them with material and especially to Mr. Robertson without whose assistance it would have been impossible to have carried out this investigation.

## PART I.

## THE OIL FROM THE SEEDS OF CHLOROXYLON SWIETENIA.

*Chloroxylon Swietenia* (satinwood) is a moderate sized tree fairly widely distributed in the dry forests of Central and South India and Ceylon especially in sandy and laterite soils.

So far as the authors are aware the oil obtainable from the seeds does not appear to have been previously investigated although Auld (Journ. Chem. Soc. Trans. 1909. 95. 964.) has examined the wood and has shown that it contains an alkaloid to which the name chloroxylonine was given, a fixed oil of specific gravity 0.965, and other bodies. The oil was present in the wood to the extent of 1 per cent. but Auld does not appear to have subjected it to a detailed investigation.

The fresh seeds from *C. Swietenia* are low in oil content and only contain 16 per cent. of an oil which from its general properties may be classed as a non-drying oil. It does not appear to possess any particularly valuable properties and the seeds cannot be considered likely to prove of any economic value.

## Experimental.

The oil was obtained from the seeds by extraction with light petroleum, when after the removal of the solvent it was obtained as a thin pale yellow oil having the following constants :— $D_{30}^{30}$  0.909,  $N_D^{30}$  1.473, acid value 9.0, saponification value 164, acetyl value nil, iodine value 84.3, unsaponifiable matter nil, Reichert-Meissl value 0.1.

For the separation of the fatty acids present in the oil, a quantity of the oil (100 grammes) was hydrolysed with alcoholic potassium hydroxide solution and after the removal of the alcohol the potassium salts were converted into the lead salts which, after drying, were separated by means of ether in the usual manner. In this way 13 grammes of solid fatty acids and 67 grammes of liquid acids were obtained.

## Identification of the Solid Acids.

The crude solid acid was converted into the methyl ester which was purified by distillation under diminished pressure (100mm.) when the following fractions were obtained :—

No.	B. P. (uncorr.)	Yield.
I . . . . .	up to 240° . . . . .	2 grammes
II . . . . .	240-250° . . . . .	2 "
III . . . . .	254-258° . . . . .	10 "

Fraction I on hydrolysis yielded an acid which after crystallisation from alcohol melted at  $54^{\circ}$  and was identified as myristic acid.

0.1002 gave 0.2704  $\text{CO}_2$  and 0.1109  $\text{H}_2\text{O}$  C=73.6, H=12.3.

$\text{C}_{14}\text{H}_{28}\text{O}_2$  requires C=73.7 H=12.3 per cent.

The amide crystallised from alcohol in minute needles melting at  $102^{\circ}$ . Fraction II consisted essentially of methyl palmitate since on hydrolysis it yielded palmitic acid melting sharply at  $62^{\circ}$ . Fraction III which formed the main bulk of the distillate yielded on hydrolysis an acid which after crystallisation from alcohol melted at  $70^{\circ}$  and was identified as stearic acid.

### Identification of the Liquid Acids.

The crude mixture of liquid acids, as separated from the lead salt, had an iodine value of 115 and obviously contained acids of a higher degree of unsaturation than oleic acid. On distillation under diminished pressure (100mm.) the following fractions were obtained:—

No.	B. P. (uncorr.)	Yield.	Iodine Value.
I. .	Up to $270^{\circ}$ . .	5 grammes	115
II. .	$270-280^{\circ}$ . .	49 „	119.2
III. ,	$280-285^{\circ}$ . .	5 „	113.7
IV .	residue . . .	8 „	..

From a consideration of the iodine values it was obvious that little separation had taken place and as further fractionation did not cause any alteration in the iodine value, the mixed acids (10 grammes) were dissolved in chloroform and treated with bromine until no further absorption took place. On removing the chloroform in vacuo a viscous semi-solid mass remained. This was ground up with dry ether and the residual solid collected, whilst from the filtrate on cooling in a freezing mixture a further quantity of solid crystallised. (Yield 1.2 grammes.)\* The crude bromo acid melted at  $183-185^{\circ}$  and after crystallisation from acetic acid it was obtained in plates which melted sharply at  $185^{\circ}$  and this melting point was unaltered on admixture with a specimen of hexabromolinolenic acid from another source.

0.1109 gave 0.1646 AgBr Br=63.3.

$\text{C}_{18}\text{H}_{30}\text{O}_2\text{Br}_6$  requires Br=63.3 per cent.

\* This corresponds with a content of 4.4 per cent. linolenic acid in the mixed liquid acids. From the iodine value of the mixture (115) it should contain, assuming only linolenic and oleic acids to be present, 10 per cent. of linolenic acid.



The ethereal extract containing the soluble bromo acids was evaporated in vacuo and the residual viscid oil ground up with ice-cold light petroleum when no solid separated even on keeping for some time in a freezing mixture. It would therefore appear that linolic acid was absent from the mixture of liquid acids.

In order to identify the other acids present a further quantity of the crude mixture of acids was converted into the barium salt which was purified by crystallisation from moist benzene from which solvent a considerable quantity was ultimately obtained in thin fine needles which gave on analysis the following figures:—

0.2489 gave 0.0845  $\text{BaSO}_4$  Ba=20.0.

$\text{C}_{36}\text{H}_{66}\text{O}_4\text{Ba}$  requires Ba=19.6 per cent.

The acid recovered from the pure barium salt was found to boil at  $280\text{--}282^\circ\text{--}100\text{mm.}$  (uncorr.) and to possess the following constants:—

$D_{\frac{30^\circ}{30^\circ}} 0.8895$ ,  $N_D^{30^\circ} 1.458$ , iodine value 89.9,  $M=281$ .

It evidently consisted of pure oleic acid.

### Summary.

The seeds of *Chloroxylon Swietenia* yield 16 per cent. of a non-drying oil.

2. The acids present in the oil as glycerides were found to be stearic, palmitic, myristic, oleic and linolenic acids.

4. The oil would not appear to be of any economic value.

## PART II.

## THE OIL FROM CALOPHYLLUM WIGHTIANUM.

*Calophyllum Wightianum* is a fairly large evergreen tree common on the banks of rivers and it also occurs in evergreen forests along the Western Ghats from Kanara southwards. The seeds are found in large quantities on the shores of estuaries. Owing to the fact that it is stated to have toxic properties the oil is not used as a foodstuff but finds local application as an illuminant amongst the poor classes.

The oil from *C. Wightianum* does not appear to have been examined previously although the oil from the closely related *C. Inophyllum* L. has formed the subject of previous investigations (Lewkowitsch, Oils and Fats. Vol. II. p. 309). The latter oil appears to find a considerable market and it seemed therefore of interest to examine the oil from *C. Wightianum* in order to determine in how far it resembled in its general properties the oil from *C. Inophyllum*.

From a consideration of the constants given in Table I it will be apparent at once that the two oils resemble one another very closely and there would appear to be little doubt that the oil from the seeds of *C. Wightianum* could be used for the same purposes as the oil from *C. Inophyllum*.

TABLE I.

	Original oil from <i>C.</i> <i>Wightianum</i> .	Refined oil from <i>C.</i> <i>Wightianum</i> .	Original oil <i>C. Inophyl-</i> <i>lum</i> . (2)	Refined oil from <i>C.</i> <i>Inophyllum</i> . (2)
D $^{27^{\circ}}$ $_{27^{\circ}}$	0.9317	0.932	0.9415	..
N $^{27^{\circ}}$ D	1.477	1.4759	1.4772	..
Acid value	38.3	2.1	...	...
Saponification value	161.7	203.8	198.7	191
Acetyl value	<i>nil</i>	<i>nil</i>	...	...
Unsaponifiable matter	<i>vi</i>	<i>nil</i>	...	...
Roichert-Meissl value	0.2	<i>nil</i>	...	...
Iodine value	92.9	103.0	95.3	86.0
Titre test	20.5	16.5	...	...
Resin acid (1)	10.4	<i>nil</i>	18.3	...

(1) This was determined by the method described below.

(2) Quoted from Lewkowitsch op. cit. p. 370.

### Experimental.

The seeds were found to consist of 25 per cent. of shells and 75 per cent. of kernels and the latter yielded, on expression in the cold in a hydraulic press, 34 per cent. of a deep orange coloured oil which had a strong resinous smell. The constants of the oil are given in the above table.

### Free acids.

A quantity of the oil was shaken with a cold dilute solution of sodium hydroxide until no further acid was removed ; the alkaline solution was washed with ether to remove traces of adherent oil and acidified with dilute sulphuric acid when a resinous brown liquid was obtained. (Yield 19 per cent.)

The crude acid was found to have an equivalent of 393·7, iodine value 87·3 and titre test 18·5. For the determination of the resin acids present the following method was adopted (c.f. Dieterich Analysis of Resins p. 99). The acid (0·9463 gramme) was neutralised with alcoholic potassium hydroxide solution, the solution made up to 100cc. by the addition of ether and finely divided silver nitrate (1·5 gramme) was added. On thoroughly shaking the solution the silver salts of the fatty acids were precipitated leaving the resin acids in solution in the ether. After filtration the clear ethereal solution (50cc.) was shaken with excess of hydrochloric acid, filtered dried and evaporated when the residue consisting of the resin acids and a little oleic acid was found to weigh 0·2431 gramme. After correcting for the oleic acid present the percentage of resin acids in the free acids was found to be 50·2 per cent.

For the identification of the fatty acids present a quantity of the crude acids was converted into the lead salt and the portion of the lead salt soluble in ether was decomposed and the recovered acid distilled under diminished pressure (100mm.) when the main fraction passed over at 276-280° leaving a considerable residue in the flask. The mixture of acids thus obtained had an iodine value of 119. A portion of the acid (10 grammes) was dissolved in chloroform and treated with bromine in the usual manner, the mixture of bromo acids thus obtained being triturated with cold light petroleum, when a small quantity of a sparingly soluble acid remained. This was recrystallised from light petroleum when it was found to melt at 114° and was identified as tetrabromolinolic acid.

Owing to the small quantity of material available it was not possible to separate the oleic acid which was undoubtedly also present in a pure state, whilst linolenic acid was absent.

The solid acids present in the "free acids" were obtained in too small a quantity for identification. The free acids present had approximately the following composition :—resin acids 50 per cent., oleic acid 38 per cent., linolic acid 10 per cent., solid acids 2 per cent.

### Combined Acids.

A quantity of the oil which had been washed with alkali to remove the free acids was hydrolysed with alcoholic potassium hydroxide solution and the liquid and solid acids separated by means of their lead salts when from 100 grammes of oil 75 grammes of liquid acids and 11 grammes of solid acids were obtained.

The liquid acids were distilled under diminished pressure (100mm.) when the following fractions were obtained :—

No.	B. P. (uncorr.)	Iodine value.
I . . .	up to 270° . . . .	121
II . . .	274-276° . . . .	101
III . . .	280-285° . . . .	122

A portion of the mixed acids was brominated in chloroform solution and after removal of the solvent, the viscid oil was triturated with ice cold ether in which it was found to be completely soluble indicating the absence of hexabromolinolenic acid. After removing the ether the oil was ground up with light petroleum when a sparingly soluble acid remained which after crystallisation from hot light petroleum was obtained in prismatic needles melting at 114° and was identified as tetrabromolinolic acid.

0.111 gave 0.14 AgBr Br=53.6.

$C_{18} H_{32} O_2 Br_4$  requires Br=53.2 per cent.

The crude bromo acid which was soluble in light petroleum evidently consisted mainly of dibromooleic acid containing a little tetrabromolinolic acid since it gave on analysis the following figures :—

0.293 gave 0.2539 AgBr Br=39.4.

$C_{18} H_{34} O_2 Br_2$  requires Br=36.2 per cent.

A further quantity of the liquid acids was converted into the barium salt and the latter purified by repeated crystallisation from moist benzene when pure barium oleate was obtained.

0.1245 gave 0.0422 BaSO<sub>4</sub> Ba=19.9.

$C_{18} H_{36} O_4 Ba$  requires Ba=19.6 per cent.

The oleic acid separated from the barium salt was found to distil at 280-282° 100mm. (uncorr.) and had the following constants :—

$D_{20}^{30}$  0.889,  $N_D^{30}$  1.4583, iodine value 90.0.

The solid acids (11 grammes), separated from the lead salts which were insoluble in ether, were fractionally converted into the magnesium salt by means of magnesium acetate in alcoholic solution when the following fractions were obtained :—

Fraction.	Yield.	M. P. (crude acid)	M. P. (recrystallised acid)	Equivalent.
I. . .	1.3 grammes	68-70°	70°	287
II. . .	1.4 „	68-70°	70°	282
III. . .	1.3 „	68-70°	70°	280
IV. . .	1.2 „	60-65°	69-70°	280
V. . .	1.3 „	60-62°	62°	258
VI. . .	1.2 „	60-62°	62°	254
VII. . .	1.2 „	60-62°	62°	258

From the above results it is clear that the solid acids present consisted of approximately equal parts of stearic acid ( $M=284$ ) and palmitic acid ( $M=256$ ). No other acids could be detected.

### Summary.

The seeds of *C. Wightianum* yielded on expression 34 per cent. of an oil which resembled closely the oil obtained from the seeds of *C. Inophyllum*.

2. The oil contained about 10 per cent. of resin.

3. The acids present in the form of glycerides were stearic, palmitic, oleic and linolic acids.



## PART III.

### THE OIL FROM THE SEEDS OF MIMUSOPS ELENGI.

*Mimusops Elengi* occurs as a scattered tree in the evergreen forests both wet and dry from the Central Provinces southwards. It also occurs in Burma in the evergreen forests especially in the Tenasserim circle. It is however nowhere very common.

Locally the oil is obtained from the seeds by boiling them, after maceration, with water and skimming off the oil which rises to the surface. It is used externally as a remedy in rheumatism.

The seeds of *Mimusops Njave* or *Djave*, which occur in West Africa, the Cameroons, Gaboon, and Nigeria yield 43-46 per cent. of a white fat which is solid at the ordinary temperature and which is used for culinary purposes.

An investigation of the oil present in the seeds of *M. Elengi* has shown that it possesses quite different properties. The oil, a liquid at the ordinary temperature, was obtained by extraction and was only present in the seeds to the extent of 16 per cent. The seeds therefore have no economic value.

### Experimental.

The oil obtained by extraction with light petroleum had the following constants :— $D_{25}^{25}$  0.9113,  $N_D^{30}$  1.4655, acid value 2.2, saponification value 188, acetyl value 12.0, unsaponifiable matter 1.3, iodine value 82.2, titre test 24.5.

On hydrolysis of 100 grammes of the oil 18 grammes of solid acids and 52 grammes of liquid acids were obtained.

### Identification of the Solid Acids.

The solid acid separated from the insoluble lead salt was dissolved in alcohol and fractionally precipitated with magnesium acetate when the following fractions were obtained :—

Fraction.	Yield.	M. P. (crude acid).	M. P. (recrystallised acid).	Equivalent.
I . .	1.8 grammes	69-70°	73-74°	329
II . .	2.0 "	69-70°	70°	293
III . .	2.0 "	69-70°	70°	288
IV . .	1.9 "	69-70°	70°	280
V . .	2.0 "	60-61°	62-65°	276
VI . .	2.2 "	60-61°	62°	262
VII . .	2.0 "	60-61°	62°	254
VIII . .	2.0 "	60-61°	62°	258

Fractions III and IV were identified as pure stearic acid and fractions VII and VIII as pure palmitic acid, whilst Fractions V and VI were apparently a mixture of these two acids. The nature of the acid present in Fraction I could not be definitely determined as it was only obtained in very small quantity. It was a saturated acid and gave on analysis the following figures :—

O·0885 gave O·2526 CO<sub>2</sub> and O·0931 H<sub>2</sub>O, C=77·8, H=12·3.

C<sub>22</sub>H<sub>44</sub>O<sub>2</sub> requires C=77·6, H=12·9 per cent.

It would therefore appear possible that this acid consisted of impure behenic acid which is stated to melt at 84° and has an equivalent of 340.

### Identification of the Liquid Acids.

The crude liquid acid had an iodine value of 82 and on distillation under diminished pressure (100mm.) the following fractions were obtained :—

No.	B. P. (uncorr.)	Iodine value.	Yield (per cent.)
I . .	270-276°	85·3	10·8
II . .	278-280°	88·3	78·2
III .	280-285°	94·4	10·8

From a consideration of the iodine values the acid would appear to consist solely of oleic acid and attempts to prepare a solid bromo acid were unsuccessful. The barium salts prepared from Fractions II and III gave on analysis the following figures :—

I. O·2309 gave O·0756 BaSO<sub>4</sub> Ba=19·3.

II. O·2264 gave O·076 BaSO<sub>4</sub> Ba=19·7.

C<sub>36</sub> H<sub>66</sub>O<sub>4</sub> Ba requires Ba=19·6 per cent.

These analyses which were made with the unpurified barium salts confirm the absence of acids other than oleic acid.

### Summary.

The seeds from *Mimusops Elengi* have been found to yield on extraction 16 per cent. of an oil.

2. The acids present in the oil were shown to be stearic, palmitic and oleic acids together with a small quantity of another saturated acid which was not identified but which was possibly behenic acid.

## PART IV.

### THE FAT FROM THE SEEDS OF *SHOREA ROBUSTA*.

*Shorea robusta* (Sal) is found along the foot of the Himalayas into Assam and in a belt in Central India.

In the Central Provinces according to Mr. G. M. Townshend the seeds are available in large quantities and might be used as a source of fat, but elsewhere apparently the seed years are too irregular to give a constant supply of seed.

At the request of Mr. Townshend an examination of the fat present in the seeds of *Shorea robusta* has been made.

On extraction the seeds were found to yield 16.4 per cent. of a fat which in its general properties resembled the fat known as Borneo tallow which is obtained from the kernels of *S. stenoptera*, *aptera*, *compressa*, *falcifera*, *gysbertiana*, etc. In view of the very low oil content of the seeds as compared with these other species, which in the case of *S. stenoptera* is stated to be 50 per cent., there would appear to be little likelihood of the seeds of *S. robusta* being of economic value.

### Experimental.

The fat was obtained on the removal of the solvent as a dark green solid which melted to a yellow oil. It had the following constants:—  
M. P. 26.5°, M. P. of fatty acids 51.5°, acid value 14.0, saponification value 181, acetyl value *nil*, unsaponifiable matter 0.32 per cent., iodine value 36.02, Reichert-Meissl value 0.50.

The crude fat (100 grammes) was hydrolysed with alcoholic potassium hydroxide solution and the mixture of acids thus obtained separated by means of the lead salts in the usual manner when 47 grammes of solid acids and 30 grammes of liquid acids resulted.

### Identification of the solid acid.

The crude solid acid which melted at 68-70° was esterified with methyl alcohol and the resulting ester distilled under diminished pressure (100mm.) when the whole passed over at about 258-260° (uncorr.). The distillate immediately crystallised and was found to melt at 38°. This melting was unchanged on recrystallisation from methyl alcohol.

0.1065 gave 0.2988 CO<sub>2</sub> and 0.1231 H<sub>2</sub>O, C=76.5, H=12.8.

C<sub>19</sub>H<sub>38</sub>O<sub>2</sub> requires C=76.5, H=12.8 per cent.

On hydrolysis the ester yielded pure stearic acid melting at 69-70° and no other solid acids could be detected.

**Identification of the liquid acid.**

The liquid acid had an iodine value of 89·6 and on distillation under diminished pressure (100mm.) was found to pass over at 280°. This acid was evidently practically pure oleic acid since it had the following constants :— $D_{30}^{30}$  0·8889,  $N_D^{30}$  1·4583, iodine value 89·6. The barium salt which appeared to be quite homogeneous gave the following figures on analysis :—

0·2315 gave 0·0796  $BaSO_4$  Ba=20·2.

$C_{36}H_{66}O_4$  Ba requires Ba=19·6 per cent.

**Summary.**

The seeds of *Shorea robusta* yield 16·4 per cent. of a fat resembling Borneo tallow. The yield of fat is too low for these seeds to be utilised as a source of fat.

2. The acids present in the fat as glycerides are stearic and oleic acids.

## PART V.

### THE FAT FROM THE SEEDS OF GARCINIA CAMBODIA.

*Garcinia Cambogia* is a small evergreen tree occurring in the evergreen forests of the Malabar coast and the Western Ghats up to 6,000 feet in the Nilgiris. It also occurs in Ceylon.

The fat does not appear to be used locally but the fruit is used as a tamarind substitute in the preparation of curries.

Although the fat from *G. Cambogia* has not been previously examined, a number of fats from other species of *Garcinia* have been described. The most important are those obtained from *G. Morella* known as *Gamboge* butter and *G. indica* known as Kokum butter. The properties of these fats are described by Lewkowitsch (op. cit. pp. 551, 597, 600.).

The fat from *G. Cambogia* resembled in its general properties the fats from the other species of *Garcinia* and provided it is available in sufficient quantity should prove of equal economic value.

### Experimental.

The seeds after grinding to a fine meal were extracted with light petroleum when a yield of 36 per cent. of fat calculated on the dry kernels was obtained. The fat which had a granular structure was nearly colourless and had the following constants :—M. P.  $29\cdot5^{\circ}$ , acid value  $5\cdot0$ , saponification value  $203\cdot5$ , acetyl value *nil*, iodine value  $52\cdot5$ , unsaponifiable matter  $1\cdot0$ , Reichert-Meissl value  $0\cdot2$ , titre test  $51\cdot2^{\circ}$ .

A quantity of the fat was saponified with alcoholic potassium hydroxide solution and the solid and liquid acids separated by their lead salts when 100 grammes of fat gave 50 grammes of solid acids and 23 grammes of liquid acids.

### Identification of the solid acid.

The solid acid consisted apparently of pure stearic acid since after crystallisation from alcohol it melted at  $69\cdot5^{\circ}$  and this melting point was not altered on admixture with stearic acid from another source.

$0\cdot102$  gave  $0\cdot2833$   $\text{CO}_2$  and  $0\cdot113$   $\text{H}_2\text{O}$ ,  $\text{C}=75\cdot7$ ,  $\text{H}=12\cdot3$ .  
 $\text{C}_{18}\text{H}_{36}\text{O}_2$  requires  $\text{C}=76\cdot1$ ,  $\text{H}=12\cdot7$  per cent.

The amide crystallised in needles and melted  $110^{\circ}$ .



**Identification of the liquid acid.**

The liquid acid had an iodine value of 80.1 and on distillation under diminished pressure yielded the following fractions:—

No.	B. P. (uncorr.) (100mm.)	Iodine value.	Yield per cent.
I . . .	268-275°	81	8
II . . .	276-280°	88.9	72
III . . .	280-285°	89.0	8
IV . . .	286-290°	...	8

Fraction IV crystallised almost completely on keeping and was found to consist of stearic acid. The main fraction (II) was almost pure oleic acid which, however, from the analytical data obtained, contained a trace of an impurity which was not removed by redistillation. The barium salt after crystallisation from moist benzene was analysed.

0.2386 gave 0.0816 BaSO<sub>4</sub> Ba=20.0.

C<sub>36</sub>H<sub>66</sub>O<sub>4</sub> Ba requires Ba=19.6 per cent.

A sample of the acid regenerated from the barium salt had the following constants :— $\frac{30^\circ}{30^\circ}$  0.89,  $N_D^{30}$  1.458, iodine value 88.8. Analysis indicated that it still contained some impurity.

0.0922 gave 0.2548 CO<sub>2</sub> and 0.0996 H<sub>2</sub>O, C=75.4, H=12.0.

C<sub>18</sub>H<sub>34</sub>O<sub>2</sub> requires C=76.6, H=12.1 per cent.

The silver salt was also analysed.

0.2411 gave 0.0687 Ag Ag=28.5.

C<sub>18</sub>H<sub>33</sub>O<sub>2</sub>Ag requires Ag=28.4 per cent.

The nature of the impurity present could not be determined nor could any liquid acids other than oleic acid be detected in Fractions I and III.

**Summary.**

*Garcinia Cambogia* seeds yield 31 per cent. of a fat resembling in its general properties the fats from other species of *Garcinia*. It should prove an excellent edible fat.

2. The acids present in the form of glycerides were identified as stearic and oleic acids.

(Received 5th April 1922.)

Forest Research Institute and College,  
Dehra Dun.



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VOL. IX

PART IV

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*Forest Research Institute, Dehra Dun.*



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*Forest Research Institute, Dehra Dun.*



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# INDIAN FOREST RECORDS

Vol. IX

1922

Part IV

## THE CONSTITUENTS OF SOME INDIAN ESSENTIAL OILS.

PARTS I—VII.

BY

JOHN LIONEL SIMONSEN

AND

MADYAR GOPAL RAU.

### INTRODUCTION.

In recent communications from these laboratories (Journ. Chem. Soc. Trans. 1920. *117*. 570, 1921. *119*. 1644, 1922. *121*. 876, Journ. Soc. Chem. Ind. 1920. *XXXIX*. 296T., 1921 *XL*. 126T. Ind. For. Rec. *VIII*. 368,) the constituents of a number of Indian essential oils have been described. It now appears desirable to place on record the results of a series of investigations on other oils. A number of these have been the subject of previous investigations but in the majority of cases only the constants of the oils were determined, no attempt having been made to isolate the actual constituents present. For a correct economic valuation of essential oils it is necessary that the actual constituents present should be determined, whilst investigations of this nature are also of considerable scientific interest.

The authors wish to express their thanks to Mr. Guest for distilling the oleoresins of *Pinus Khasya* and *Pinus excelsa* at Jallo; to Mr. Hole for botanical identifications and to Mr. Robertson for arranging for the collection of much raw material. Our thanks are also due to Mr. Ghose for assistance in the analytical work.

## PART I.

**The Essential Oil from the Oleo-resin of *Pinus Khasya*.**

The oleo-resin from *Pinus Khasya* from Burma has already formed the subject of a number of previous investigations. Armstrong (Pharm. Journ. 1891. 3. 21, 1896. 56. 370.) would appear to have been the first to examine this oleo-resin, whilst subsequently it was investigated by Puran Singh in these laboratories. Full details of the results of these previous investigations are to be found in Forest Bulletin No. 24 (1913). In this paper the geographical distribution and the quantity of *Pinus Khasya* for tapping available are fully dealt with so that further reference to these subjects is unnecessary here.

The high quality of the turpentine was recognised by previous investigators who further suggested, that it consisted essentially of  $\alpha$ -pinene but afforded no proof of this beyond the physical constants.

For the experiments described below a large quantity of the oleo-resin was distilled on a commercial scale at Jallo and the bulk oil immediately sealed up in tins and forwarded to the authors for examination. The following are the details of the results of the distillation of the oleo-resin :—

104·7 maunds of the oleo-resin were distilled and 164 gallons of turpentine were obtained which represented 1·6 gallons of turpentine per maund of resin as compared with a yield of 2·0 gallons from a maund of the oleo-resin of *P. longifolia*. On re-distillation in steam under the ordinary conditions adopted at the factory the following results were obtained :—

Turpentine	quality I.	1·30	gallons	per	maund	of	crude	resin.
"	"	II.	0·13	"	"	"	"	"
"	"	III.	0·10	"	"	"	"	"
Loss on re-distillation		0·07	"	"	"	"	"	"
Total		1·6						

The rosin yield was :—

Clean rosin	53·42	maunds	(51 per cent. by weight of crude resin treated).
Dirty rosin	6·33	maunds	( 6 per cent.        "        "        "        "        ).
Total	59·8	maunds	(57 per cent.        "        "        "        "        ).

(One maund is equivalent to 82 lbs.)

As compared with *P. longifolia*, which yields 70 per cent. of rosin, the yield is somewhat poor, whilst the proportion of dirty rosin to

clean is also higher than in the case of *P. longifolia* where it averages 2 per cent. The rosin was however of good quality and was classed as M. grade.

As will be seen from the sequel the turpentine was much superior in quality to that from *P. longifolia*, being quite equal to American turpentine. There can be little doubt that, provided the oleo-resin could be collected and delivered at the factory at a cost of Rs. 10 per maund, the distillation would prove highly remunerative.

A careful examination of the oil has shown that it contains *d*- $\alpha$  pinene, *d*- $\beta$ -pinene whilst from the higher boiling fraction longifolene was isolated identical in all respects with the sesquiterpene present in *P. longifolia*. The presence of the same sesquiterpene in *P. Khasya* as in *P. longifolia* is of considerable interest in view of the close botanical relationship of these two pines.

### Experimental.

The oil as received from the factory was carefully dried over anhydrous magnesium sulphate and was found to have the following constants :— $D_{\frac{30}{30}}^{\frac{30}{30}}$  0.8633,  $N_D^{30}$  1.4675,  $[\alpha]_D^{30}$  +32.83°, acid value 1.9. It was pale yellow in colour and was indistinguishable in smell from American turpentine.

A considerable quantity was fractionated at the ordinary pressure (706 mm.) using a twelve pear Young still head when the following fractions were obtained :—

No.	B. P.	Yield per cent.	$D_{\frac{30}{30}}^{\frac{30}{30}}$	$N_D^{30}$	$[\alpha]_D^{30}$
I	153—156° . .	42.2	0.8546	1.4625	+38.3°
II	156—160° . .	29.5	0.855	1.4637	+34.6°
III	160—165° . .	9.5	0.8556	1.4665	+27.48°
IV	Residue in flask .	15.2	...	...	...

The residue in the flask which consisted mainly of a sesquiterpene was repeatedly refractionated under diminished pressure (39mm.) when it was separated into two main fractions (A) boiling below 135° and (B) boiling from 135—160°. Fraction A was refractionated at the ordinary pressure (706mm.) using a twelve pear Young still head when it was found to distil mainly between 160-175°. The fraction distilling

between 160—165° being added to fraction III (see above), whilst three other small fractions 165—170°, 170—175°, 175—230° were collected separately. The following percentage yields were obtained :—

No.	B. P.	Yield per cent.
I	153—156°	42.2
II	156—160°	29.5
III	160—165°	9.9
IV	165—170°	4.1
V	170—175°	1.4
VI	175—230°	1.5
VII	135—160/39mm.	7.5

By further systematic fractionation at the ordinary pressure (703mm.) thirteen fractions having the following boiling points and constants were obtained :—

No.	B. P.	Yield per cent.	D <sub>30°</sub> <sup>30°</sup>	N <sub>D</sub> <sup>30°</sup>	30° [α] <sub>D</sub>
I	153—155° . .	49.6	0.8536	1.462	+ 40.62°
II	155—157° . .	16.3	0.8548	1.463	+ 36.12°
III	157—159° . .	4.7	0.8555	1.4645	+ 30.06°
IV	159—161° . .	4.2	0.8555	1.4657	+ 27.18°
V	161—163° . .	2.0	0.8561	1.467	+ 23.21°
VI	163—165° . .	2.4	0.8559	1.4633	+ 19.02°
VII	165—167° . .	2.0	0.8559	1.47	+ 14.91°
VIII	167—169° . .	1.1	0.8565	1.4715	+ 10.92°
IX	169—171° . .	1.1	0.8555	1.473	+ 7.2°
X	171—173° . .	1.2	0.8549	1.4745	+ 4.88°
XI	173—175° . .	0.2	...	...	...
XII	170—240° . .	2.8	...	...	...
XIII	135—160°/39mm. .	7.5	...	...	...

From a consideration of the physical constants it was clear that fractions I-III consisted of *d*- $\alpha$ -pinene and the presence of this hydrocarbon was confirmed by the preparation of the nitrosochloride melting at 105—106° and the nitrolpiperide melting at 118—119°. Fractions IV-VIII were found to consist essentially of a mixture of *d*- $\alpha$ -pinene and *d*- $\beta$ -pinene. The former hydrocarbon was identified by means of its nitrosochloride, whilst the latter was converted into nopinic acid by oxidation with potassium permanganate in the usual manner. The nopinic acid obtained melted at 125—127°.

The nature of the hydrocarbons present in fractions IX-XI could not be determined.  $\beta$ -pinene was present in all these fractions but none of the commoner monocyclic terpenes could be detected. Fraction XII consisted essentially of impure sesquiterpene no alcohols being present.

The sesquiterpene fraction XIII on redistillation was found to boil very constantly at 151°/37mm. and at 252—254°/706mm. After repeated distillation over sodium it had the following constants :—

$D_{30}^{30}$  0·9236,  $N_D^{30}$  1·497,  $[\alpha]_D^{30} +36\cdot69^\circ$

0·0777 gave 0·2522-CO<sub>2</sub> and 0·0828 H<sub>2</sub>O, C=88·5, H=11·8.

C<sub>15</sub>H<sub>24</sub> requires C=88·2, H=11·8 per cent.

The sesquiterpene *d*-longifolene (Journ. Chem. Soc. Trans. 1920. 117. 578.) had constants agreeing fairly closely with these and the identity of the two hydrocarbons was established by the preparation of the hydrochloride, hydrobromide and the hydroiodide of the terpene from *P. Khasya*. These melted respectively at 59-60°, 69-70°, and 71°. No alteration in the melting points was observed on admixture with specimens of these derivatives prepared from the hydrocarbon from *P. longifolia*.



## PART II.

**The Essential Oil from the Oleo-resin of *Pinus excelsa*.**

In a short communication from these laboratories (Puran Singh. Forest Bulletin. No. 24. (1913) ) brief mention was made of the turpentine distilled from the oleo-resin of *Pinus excelsa*. The constants of the oil were determined whilst the distribution of and the approximate area under *P. excelsa* were also given. No attempt however was made to determine the constituents present in the oil and in view of the interesting results obtained in the investigation of the turpentines from *P. longifolia* and *P. Khasya* it was decided also to examine this oil.

Through the kindness of Mr. Guest a quantity of the oleo-resin of *P. excelsa* was distilled at the Government Turpentine Factory at Jallo and Mr. Guest has furnished me with the following table of the results of the distillation ; for comparison the results of the distillation of the oleo-resins from *P. longifolia* and *P. Khasya* are also given.

TABLE I.

—	<i>P. excelsa.</i>	<i>P. longifolia.</i>	<i>P. Khasya.</i>
Yield of turpentine per maund of resin.	2·25 gals.	2·0 gals.	1·6 gals.
Commercial fractionation. Yield per maund of resin.	...	...	..
Quality I . . .	2 „	1·4 „	1·3 „
„ II . . .	...	0·3 „	0·13 „
„ III . . .	...	0·22 „	0·10 „
Loss . . . .	...	0·08 „	0·07 „
Yield of rosin % in crude resin.	68	70	60

From these results it is clear that the turpentine from *P. excelsa* is of excellent quality, but as the oleo-resin yield of the trees is low and they are also somewhat inaccessible, it is doubtful if it is commercially feasible to undertake the distillation.

The results of a careful examination of the turpentine have proved of more than ordinary interest. Careful fractional distillation of the oil has shown that it consists of *d*- $\alpha$  pinene of remarkable purity (87.9 per cent), *d*-terpineol, a bicyclic sesquiterpene  $C_{15}H_{24}$ , and a small quantity of a saturated hydrocarbon of the formulæ  $C_{11}H_{24}$ .

Owing to the very small percentage of the last named constituent which was present, its separation from the oil in a pure state offered very considerable difficulty. It was found to boil at 191-192°/705mm. and had the constants  $D_{30}^{30}$  0.7353,  $N_D^{30}$  1.414. From a consideration of these figures together with the results of the analysis and molecular weight determination (see page 11) there can be little doubt that this hydrocarbon was *n*-undecane. This hydrocarbon was isolated by Mabery (Am. 1897. 19.419,) and Mabery and Hudson (Am. 1897. 19. 482.) from Pennsylvanian and Ohio petroleum and it has also been studied by Krafft (Berichte. 1882.15.1697.) and Ross and Leather. (Analyst. 1906. 31. 284.) The last named investigators found this hydrocarbon to boil at 193-195°/754mm. and to have the following constants:— $D_{15}^{15}$  0.7466,  $N_D^{15}$  1.41817 which recalculated to 30° give the following values  $D_{30}^{30}$  0.73525,  $N_D^{30}$  1.41217 which agree very closely with the values found by the authors for their hydrocarbon. The identification of a paraffin hydrocarbon is always a matter of considerable difficulty and unfortunately the authors had not sufficient material available for the preparation of derivatives. They do not however consider that there can be any doubt that their hydrocarbon is identical with *n*-undecane. When oxidised with nitric acid succinic acid was the only product which could be isolated.

The separation of a saturated hydrocarbon of the paraffin series from the coniferæ appears to be of more than ordinary interest. With few exceptions the hydrocarbons obtained from the oleo-resins have the formulæ  $C_{10}H_{16}$  or  $C_{15}H_{24}$  and are unsaturated. The only exceptions which the authors have been able to find are the two turpentines from *P. Sabiniana* and *P. Jeffreyi* both of which consist essentially of the hydrocarbon heptane, whilst Baker and Smith (The Pines of Australia, page 33) have separated from the latex of *Araucaria Cunninghamii* two hydrocarbons of the formulæ  $C_{10}H_{18}$  and  $C_{10}H_{20}$ .

Apart from *P. lambertiana*, *P. excelsa* would appear to be the first member of the "*strobis*" (five leafed) group of pines the oleo-resin of which has been examined and in view of the results obtained it would appear desirable that other members of this group should be examined in order to determine if they also contain hydrocarbons of the paraffin series. There would appear to be some evidence for the occurrence

of a member of this series in the oil from *P. lambertiana* since it is stated to contain a small quantity of an aliphatic hydrocarbon which was not identified.

The opinion is now generally held that the petroleum oils are of organic origin. In view of the fact that the remains of coniferæ have been found in the early strata it would appear to be possible that they were, at any rate in certain areas, one of the sources of the petroleum now found there. The isolation of two members of the paraffin series, which are also present in American petroleums from the oleo-resins of coniferæ, would tend to support this view and it is highly desirable that the oils from some of the more primitive members of this species, such as the *Araucariæ*, should be carefully examined.

### Experimental.

The oil used in this investigation was pale yellow in colour with a smell resembling that of American turpentine. It was found to have the following constants :— $D_{30}^{30}$  0·857,  $N_D^{30}$  1·4627,  $[\alpha]_D^{30} +40\cdot42^\circ$ , acid value nil\*, saponification value 4·11, saponification value after acetylation 9·11. A quantity of the oil was distilled under diminished pressure (200mm.) when the following fractions resulted :—

No.	B. P.	Yield per cent.
I	109-111°	61·5
II	111-130°	31·0
III	residue by difference	7·5

Fractions I. and II. were distilled under the ordinary pressure (707mm.) using a Young four pear still head when the following fractions were obtained :—

No.	B. P.	Yield per cent.
I	153-155°	87·9
II	155-160°	0·6
III	160-165°	0·8
IV	165-170°	0·6
V	above 170° (by difference)	2·6

\* The absence of any free acids removes the possibility of undecane having been formed by the decarboxylation of a fatty acid during the distillation.

*Fraction I.* This fraction on distillation over sodium boiled very constantly at 153·8-154°/708mm. and had the following constants :— $D_{30}^{30}$  0·8551,  $N_D^{30}$  1·4612,  $[\alpha]_D^{30} + 43\cdot32^\circ$ . It consisted of very pure *d*- $\alpha$ -pinene and the presence of this hydrocarbon was confirmed by the preparation of the nitrosochloride and the nitrolbenzylamine derivative. *Fractions II. III. and IV.* These three fractions were found to consist essentially of *d*- $\alpha$ -pinene; no trace of  $\beta$ -pinene could be detected, since on oxidation with potassium permanganate in the usual manner nopinic acid was not formed.

*Isolation of n-Undecane C<sub>11</sub>H<sub>24</sub>.*

A preliminary examination of the fractions of the oil which boiled above 111°/200mm. indicated the presence of a hydrocarbon which had a very low density. As this hydrocarbon was only present in very small quantity, several gallons of the turpentine were systematically fractionated under diminished pressure (200mm.) using a Young still head. The bulk of the oil passed over below 111°/200mm. in the first fractionations and evidently consisted of *d*- $\alpha$ -pinene since it had the following constants :— $D_{30}^{30}$  0·8533,  $N_D^{30}$  1·412,  $[\alpha]_D^{30} + 35\cdot75^\circ$ .

The progress of the separation was followed by the determination of the physical constants of each fraction and in the three following tables are given the results of the three final fractionations :—

TABLE II.

No.	B. P. (200mm.)	$D_{30}^{30}$	$N_D^{30}$	$[\alpha]_D^{30}$
I	below 100°	0·8525	1·461	+35·5°
II	100-106°	0·8511	1·459	+35·11°
III	106-112°	0·8515	1·460	+33·92°
IV	112-118°	0·8487	1·46	+31·35°
V	118-130°	0·8343	1·454	+21·75°
VI	130-140°	0·8175	1·4476	+14·65°
VII	140-150°	0·8083	1·4429	+10·5°
VIII	150-160°	0·821	1·4482	+11·08°
IX	160-170°	0·8702	1·4690	+20·23°

TABLE III.

No.	B. P. (100mm.)	$D_{30}^{30}$	$N_{\overline{D}}^{30}$	$[\alpha]_{\overline{D}}^{30}$
I	96-102°	0.8426	1.46	+24.17°
II	102-108°	0.8276	1.457	+17.45°
III	108-114°	0.8137	1.4475	+11.06°
IV	114-120°	0.7945	1.4372	+5.75°
V	120-126°	0.7785	1.429	+7.3°
VI	126-132°	0.7923	1.4322	+11.32°
VII	132-142°	0.8412	1.452	+23.0°

TABLE IV.

No.	B. P. (100mm.)	$D_{30}^{30}$	$N_{\overline{D}}^{30}$	$[\alpha]_{\overline{D}}^{30}$
I	108-114°	0.8168	1.45	+7.04°
II	114-120°	0.7954	1.437	+5.5°
III	120-126°	0.7769	1.4265	+5.88°

The fraction boiling at 120-126°/100mm. was the main fraction all the others being comparatively small. This fraction was repeatedly distilled over sodium to remove an alcohol which was present when an oil was obtained which boiled very constantly at 125-127°/100mm. and at 190-193°/705mm. This oil had the following constants:— $D_{30}^{30}$  0.7526,  $N_{\overline{D}}^{30}$  1.4205,  $[\alpha]_{\overline{D}}^{30}$  +1.75°. On examination the hydrocarbon was found to absorb a little bromine when dissolved in chloroform, the quantity was however so small that the reaction was evidently due to the presence of a small quantity of impurity. The hydrocarbon was therefore mixed with ice and treated with a two per cent. solution of potassium permanganate until a permanent pink colour resulted. The hydrocarbon was recovered by distillation in steam and after distillation over sodium it was found to boil quite constantly



at 127°/100mm. and 191-192°/703mm. It now had the following constants:— $D_{30}^{30}$  0.7482,  $N_D^{30}$  1.4189,  $[\alpha]_D^{30} + 1.75^\circ$ . As the hydrocarbon was evidently still not quite pure (Found C=85.3, H=14.5 per cent), it was shaken with cold concentrated sulphuric acid until it no longer reacted with this reagent. The boiling point of the hydrocarbon was unchanged but the constants had altered somewhat and it was no longer optically active:  $D_{30}^{30}$  0.7353,  $N_D^{30}$  1.4140. The analysis of the hydrocarbon was attended with considerable difficulty as it tended to explode in the combustion tube but the figures obtained together with the molecular weight determination and the constants leave little doubt as to the hydrocarbon being *n*-undecane.

0.1204 gave 0.3712 CO<sub>2</sub> and 0.1651 H<sub>2</sub>O, C=84.1, H=15.2.

1.0128 in 10.54 gr. benzene gave a depression of 3.00° M.W.=157.

C<sub>11</sub>H<sub>24</sub> requires C=84.6, H=15.4 per cent. M.W.=156.

Undecane was not acted upon by concentrated sulphuric acid or nitric acid in the cold. It did not absorb bromine in chloroform solution. When heated with nitric acid (D1.22) at 180° in a sealed tube succinic acid was formed.

### *Separation of terpeneol and a sesquiterpene.*

The whole of the fractions boiling above 130°/200mm. and 126°/100 mm. were combined and heated with alcoholic potassium hydroxide solution to hydrolyse any esters present and the oil separated in the usual manner. On distillation under diminished pressure two main fractions were obtained, the first boiling at 150—170°/200mm. and the second at 150—170°/36mm.

The lower boiling fraction was identified as terpeneol by the preparation of the nitrosochloride.

The high boiling fraction was a sesquiterpene which after distillation over sodium was obtained as a somewhat viscous colourless oil with a pleasant pine like odour. It boiled at 145—146°/34mm. and had the following constants:—

$D_{30}^{30}$  0.8954,  $N_D^{30}$  1.486,  $[\alpha]_D^{30} + 26.25^\circ$   $M_D = 65.4$ .

0.1465 gave 0.4728 CO<sub>2</sub> and 0.1588 H<sub>2</sub>O, C=88.0, H=12.0

C<sub>15</sub>H<sub>24</sub> requires C=88.2, H=11.8 per cent.

This terpene could not be characterised since it did not yield any crystalline derivatives but from a consideration of its molecular refraction it was evidently bicyclic. When dissolved in acetic anhydride and treated with a drop of concentrated sulphuric acid a pale pink colour was developed which slowly became magenta.

*Combined Acids.*

The acids present in the alkaline solution from the hydrolysis of the esters were isolated after acidification by distillation in steam. The acid obtained in this manner boiled mainly at  $175-185^{\circ}/705\text{mm.}$  and evidently consisted of valerianic or *iso* valerianic acid. The silver salt was analysed.

0.2487 gave 0.1288 Ag,  $\text{Ag} = 51.8$ .

$\text{C}_5\text{H}_9\text{O}_2\text{Ag}$  requires  $\text{Ag} = 51.7$  per cent.

## PART III.

**The Essential Oil from *Cedrus Deodara*, Loudon.**

The essential oil from *Cedrus Deodara*, Loudon has already formed the subject of an investigation by Roberts (Journ. Chem. Soc. Trans. 1916. 109. 791.). The oil used for this investigation was distilled at Dehra Dun and forwarded by the Forest Economist to the Imperial Institute for examination. At the request of Mr. Howard, Silviculturist, a re-examination of this oil was undertaken owing to the importance of finding an economic use for the oil.

As there was no data showing the age of the wood from which the previous oil had been obtained, the oil having been distilled from factory shavings, a quantity of logs, 75 years old, was collected and converted into "wool" at Bareilly. On distillation in steam (pressure 30-40 lbs.) a yield of 2.5 per cent of oil was obtained. The constants of the oil compared with the oil used by Roberts are given in Table I.

TABLE I.

	S. & G. R.	R.	R.
$D_{30}^{30}$ . .	0.9592	$D_{15}^{15}$ 0.9549	0.9756
$N_D^{30}$ . .	1.5203	$N_D^{21}$ 1.5195	1.5225
$[\alpha]_D^{30}$ . .	+45.08°	$[\alpha]_D^{22}$ +52.16°	+34.6°
Acid value	1.6	5.6	4.5
Saponification value	22.1	19.3	4.9
Saponification value after acetylation.	42.3	30.8	34.4

As the result of his investigation Roberts found that the oil contained a ketone (probably *p*-methyl- $\Delta^3$ -tetrahydroacetophenone) 2 per cent, a sesquiterpene 50-70 per cent, a phenol 0.07-0.4 per cent

and the esters of hexoic, heptoic and stearic acids together with sesquiterpene alcohols. As the result of their investigation the authors can in the main confirm Robert's results. They have found the ketonic content to be somewhat higher, 8 to 10 per cent, whilst no phenol could be detected. No evidence of the presence of heptoic or stearic acids was found by the authors but butyric or isobutyric acid and hexoic acids were isolated and in addition an unidentified crystalline acid melting at 110°.

There can be little doubt that as suggested by Roberts the ketone present in the oil, which he did not succeed in obtaining pure, is *p*-methyl- $\Delta^3$ -tetrahydroacetophenone. The authors have succeeded in separating this ketone in a pure state and have identified it by conversion into its semicarbazone, oxime and dibromooxime which have the melting points given by Wallach and Rahn (Annalen. 1902. 324. 91.). When warmed with concentrated sulphuric acid it was converted into *p*-tolyl methyl ketone but they are unable to confirm the statement made by Roberts (loc. cit. p. 793.) that when the semicarbazone of the tetrahydroketone is treated with dilute sulphuric acid and distilled in steam *p*-tolyl methyl ketone is formed. Under the conditions used by the authors the pure tetrahydroketone was regenerated.

It was not found possible to identify either the sesquiterpene or the sesquiterpene alcohol since they yielded no crystalline derivatives.

Professor W. H. Perkin, F. R. S. of the University of Oxford kindly had a sample of the oil valued in England. He informed us that the oil might find a small market as a substitute for oil of cedar wood in soap perfumery. Its value would however only be 2/6 per lb. It is obvious that at this price it would not prove remunerative to convert logs into sawdust and distil over the oil in steam. On the other hand it would appear to be a matter for consideration whether it would not prove remunerative to distil the logs themselves and to use the crude wood oil thus obtained as a timber preservative. Further experiments in this direction would appear desirable.

### *Experimental.*

The constants of the oil used in this investigation are given in Table I. The oil, which was deep reddish brown in colour, had a pleasant and characteristic odour. Prior to distillation, the oil was shaken with dilute sodium hydroxide solution (N/2) to remove the free acids and any phenols present and then boiled for some hours with alcoholic potassium hydroxide solution to hydrolyse the esters. The residual

oil was separated in the usual manner and the alkaline solutions reserved for further investigation (see below).

The oil was repeatedly fractionated under diminished pressure (50mm.) when the following main fractions were ultimately obtained :—

No.	B. P.	Yield per cent.
I	116-120°	8-10
II	170-175°	40
III	195-200°	40

*Fraction I.*—This fraction to which the original oil owes its smell was, on redistillation, found to boil constantly at 116°/52mm. and at 197-199°/710mm. It had the following constants :— $D_{30}^{30}$  0.9391,  $N_D^{30}$  1.465. These are in good agreement with those found by Stephan and Helle (Ber. 1902. 35. 2151.) who prepared p-methyl- $\Delta^3$ -tetrahydroacetophenone from  $\beta$  terpineol and gave the following values  $D_{15}^{15}$  0.9435,  $N_D^{15}$  1.4742. Wallach and Rahn (loc. cit.) found that this ketone boiled at 205-206° and gave the following constants.  $D_{19}^{19}$  0.940,  $N_D^{19}$  1.4719.

0.0964 gave 0.2754  $\text{CO}_2$  and 0.0839  $\text{H}_2\text{O}$ ,  $\text{C}=77.9$ ,  $\text{H}=9.7$ .

$\text{C}_9\text{H}_{14}\text{O}$  requires  $\text{C}=78.2$ ,  $\text{H}=10.1$  per cent.

*p*-Methyl- $\Delta^3$ -tetrahydroacetophenone semicarbazone crystallised from alcohol in glistening leaflets which melted at 165°. (Roberts loc. cit. p. 793 found 163-164°.)

0.1287 gave 25.2cc.  $\text{N}_2$  at 15° and 710mm.  $\text{N}=21.3$ .

$\text{C}_{10}\text{H}_{17}\text{ON}_3$  requires  $\text{N}=21.5$  per cent.

*p*-Methyl- $\Delta^3$ -tetrahydroacetophenone oxime crystallised from dilute methyl alcohol in needles melting at 50°. (Wallach and Rahn loc. cit. gave 51.5°.)

0.0972 gave 0.2502  $\text{CO}_2$  and 0.084  $\text{H}_2\text{O}$ ,  $\text{C}=70.2$ ,  $\text{H}=9.6$ .

$\text{C}_9\text{H}_{15}\text{ON}$  requires  $\text{C}=70.6$ ,  $\text{H}=9.8$  per cent.

*p*-Methyl- $\Delta^3$ -tetrahydroacetophenone dibromooxime crystallised from alcohol in which it was somewhat sparingly soluble in rhombic plates which melted at 134-135°. (Wallach and Rahn loc. cit. found 130°.)

0.116 gave 0.1385 AgBr  $\text{Br}=50.8$ .

$\text{C}_9\text{H}_{15}\text{ONBr}_2$  requires  $\text{Br}=51.1$  per cent.

A further proof of the identity of this ketone with p-methyl- $\Delta^3$ -tetrahydroacetophenone was furnished by its conversion into p-tolyl methyl ketone when it was heated with four times its volume of concentrated sulphuric acid on the water bath for a short time. The



ketone thus obtained was converted into the semicarbazone which melted at 204-205°.

0.1261 gave 26.4ccN<sub>2</sub> at 26° and 706mm. N=22.2.

C<sub>10</sub>H<sub>13</sub>ON<sub>3</sub> requires N=22.0 per cent.

*Fraction II.*—The second fraction was purified by repeated distillation over sodium when it was obtained as a colourless highly refracting oil which boiled at 152-154°/40mm. and evidently consisted of the nearly pure sesquiterpene.

0.0967 gave 0.3148 CO<sub>2</sub> and 0.0978 H<sub>2</sub>O, C=88.7, H=11.2.

C<sub>15</sub>H<sub>24</sub> requires C=88.2, H=11.7 per cent.

The sesquiterpene was found to have the following constants :—  
D<sub>20</sub><sup>30°</sup> 0.9195, N<sub>D</sub><sup>30°</sup> 1.5010, [α]<sub>D</sub><sup>30°</sup> + 13.86°. These values may be compared with those found by Roberts (loc. cit. p. 796) for the sesquiterpene isolated by him D<sub>15</sub><sup>5°</sup> 0.9276, N<sub>D</sub><sup>21°</sup> 1.5170, [α]<sub>D</sub><sup>20°</sup> + 14.36°. When dissolved in acetic anhydride the terpene gave with sulphuric acid a port wine colour. It was not found possible to prepare any crystalline derivatives.

*Fraction III.*—This fraction which apparently consisted essentially of a sesquiterpene alcohol was ultimately obtained as a viscid yellow oil boiling at 202-204°/55mm. It had the following constants :—  
D<sub>20</sub><sup>30°</sup> 0.9578, N<sub>D</sub><sup>30°</sup> 1.515, [α]<sub>D</sub><sup>30°</sup> + 38.41°. It yielded no crystalline derivatives and could not be characterised.

0.1037 gave 0.3094 CO<sub>2</sub> and 0.0938 H<sub>2</sub>O, C=81.3, H=10.1.

C<sub>15</sub>H<sub>24</sub>O requires C=81.1, H=10.9 per cent.

#### *Free Acids.*

The alkaline solution with which the original oil had been washed was extracted with ether to remove traces of adhering oil and saturated with carbon dioxide when no separation of any phenol was observed. The solution was acidified with dilute sulphuric acid and distilled in steam when a small quantity of a crystalline acid passed over, which after crystallisation from dilute acetic acid melted at 110°. On analysis it gave the following figures C=74.4, H=9.6, M=179.9. Unfortunately it was not obtained in sufficient quantity for further purification and identification.

#### *Combined Acids.*

The alkaline solution resulting from the hydrolysis of the esters present in the oil was evaporated on the water bath until free from alcohol, made acid with dilute sulphuric acid and distilled in steam.

The distillate was collected in three fractions, whilst from a further fraction a small quantity of the crystalline acid mentioned above was isolated. The acid present in the three first fractions were converted into the silver salts which on analysis gave the following results :—

Fraction—

I	.	.	0.0647	gave 0.0352 Ag.	Ag=54.4 per cent.
II	.	.	0.1314	gave 0.0598 Ag.	Ag=45.5 „
III	.	.	0.22	gave 0.0798 Ag.	Ag=36.3 „

Fraction I evidently consisted of the silver salt of butyric or isobutyric acid ( $C_4H_7O_2Ag$  requires Ag=55.1 per cent); Fraction II of hexoic acid ( $C_6H_{11}O_2Ag$  requires Ag=45.4 per cent); Fraction III was not identified and evidently consisted of a mixture.

## PART IV.

The Essential Oil from *Andropogon Jwarancusa*,  
Jones.

In a recent communication from these laboratories (Journ. Chem. Soc. Trans. 1921. 119. 1645.) an account was given of the properties and constituents of the essential oil from *A. Jwarancusa* Jones. The grass from which the oil was obtained was grown in the Hazara District and the oil was placed at the disposal of the author by the courtesy of Colonel C. R. Johnson. An examination of the oil showed that it contained approximately 77 per cent of the interesting ketone d-piperitone ( $\Delta'$ -*p*-menthen -3-one) and since this ketone in addition to being of scientific interest may prove to be of economic value it has appeared to the authors desirable to examine the oil obtained from the same grass grown under different climatic conditions.

A quantity of the grass which occurs fairly extensively in Sind was supplied by the Divisional Forest Officer, Shikarpur and subjected to distillation in steam in the usual manner, when an oil was obtained which differed considerably in its properties from that obtained from the Hazara District.

In Table I. the constants of this oil are given alongside those of the oil from Hazara, whilst for reasons which will appear later the constants are also given of an oil described by Roberts (Journ. Chem. Soc. Trans. 1915. 107. 1465.) which was obtained from *Cymbopogon Sennaarensis*. Chiov. from the Soudan.

TABLE I.

		Oil from Hazara.	Oil from Sind.	Oil from <i>C. Sennaarensis</i> .
$D_{30}^{30}$	. . .	0.9203	0.9228	$D_{15}^{15}$ 0.9383 0.9422 }
$N_D^{30}$	. . .	1.481	1.4858	...
$[\alpha]_D^{30}$	. . .	+51.68°	+42.8°	$[\alpha]_D^{20}$ +34.14° $[\alpha]_D^{23}$ +29.3° }
Ketone per cent.	. . .	77	44	45

It will be observed that the oil from Sind, whilst having a lower rotation than the Hazara oil, had both a higher density and refractive index, whilst the percentage of ketone present was very much lower and corresponded closely with that observed by Roberts in the oil from *C. Sennaarensis*.

In the Hazara oil the only constituent present in any quantity in addition to *d*-piperitone was a terpene, up to the present not identified,\* which was obtained in a yield of about 20 per cent. The oil from Sind was apparently much more complex in its composition. In addition to piperitone (44 per cent), it contained a hydrocarbon identical probably with that present in the Hazara oil (24 per cent), an unidentified alcohol with a rose like odour (2 per cent), a sesquiterpene alcohol (28 per cent), a trace of a phenol (0.2 per cent), whilst in a free or combined state it contained palmitic acid and a mixture of acids consisting apparently of decoic and octoic acids.

These constituents resemble in a very remarkable manner those present in the oil from *C. Sennaarensis*, since Roberts (loc. cit. p. 1470.) in summarising his results has stated that the oil contained (i) ketones (chiefly or entirely piperitone) 45 per cent, (ii) terpenes 13 per cent, (iii) unidentified alcohol 3 per cent, (iv) sesquiterpene alcohol 25 per cent, (v) phenol 0.2 per cent, (vi) acids free and combined acetic, palmitic, octoic, decoic, 2 per cent.

From a consideration of these results, in the authors' opinion there can be little doubt that the oils from *A. Jwarancusa* grown in Sind and the oil from *C. Sennaarensis* grown in the Soudan are identical.

In a footnote to the previous communication on this subject Mr. R. S. Hole has discussed the taxonomy of the various forms of *A. Jwarancusa*. So far as the botanical evidence at present available goes there would not appear to be any adequate *botanical* reason for differentiating the Hazara and Sind grasses. The *chemical* evidence, on the other hand, would appear to be strongly in favour of a differentiation, although the factor of climatic conditions should not be lost sight of, since many cases are known of the marked influence of climatic and soil conditions on the chemical constituents of plants.

Attention may be directed to the somewhat wide distribution in nature of piperitone. It has now been identified in

(i) *Eucalyptus dives*. (Read and Smith. Journ. Chem. Soc. 1921 119. 779).

(ii) *C. Sennaarensis*. Chiov. (Roberts. loc. cit.).

\* Note added 9-8-22. This terpene has since been identified as *d*- $\Delta^4$  carene.

(iii) Japanese peppermint oil (Schimmel and Co. Report 1910. 97).

(iv) *Cymbopogon proximus* from the Soudan (Roberts. private communication).

### Experimental

The oil, which was obtained from the grass in a yield of 0.36 per cent, was pale brown in colour and had the constants given in Table I. It had a fresh odour of peppermint and resembled the Hazara oil but was somewhat harsher. When distilled under diminished pressure (200 mm.) the following fractions were obtained :—

No.	B. P.	Yield per cent.
I	up to 140°	7.6
II	140-170°	24.8
III	170-190°	30.4

The pressure was then reduced to 100mm. and two further fractions were taken :—

IV	170—190°	12.4
V	190—220°	21

A considerable residue remained in the distilling flask.

The first four fractions were shaken with a hot neutral solution of sodium sulphite until the ketone was completely removed, a process which takes some days, and the residual oil was distilled under diminished pressure (200mm.), the fraction passing over below 140° (24 per cent) was collected separately, whilst the fraction boiling above that temperature was added to fraction V from the first distillation.

The fraction which boiled below 140°/200mm. was refractionated at the ordinary pressure (707mm.) when practically the whole distilled at 165-170° and on redistillation over sodium it distilled very constantly at 165.5-167°/707mm. This terpene was evidently identical with that isolated from the oil from Hazara as will be seen from a consideration of the constants which are given in Table II.



TABLE II.

	<i>Hazara Terpene.</i>	<i>Sind Terpene.</i>
B. P.	163-164°/698mm.	165.5-167°/707
D $\frac{30^\circ}{30^\circ}$	0.8565	0.8552
N $\frac{30^\circ}{D}$	1.474	1.474
[ $\alpha$ ] $\frac{30^\circ}{D}$	+54.82°	+62.2°
M $\frac{30^\circ}{D}$	44.62	44.69

The constitution of this terpene has not up to the present been elucidated, experiments on the subject being still in progress. From a consideration of the molecular refraction the terpene would appear to be bicyclic.\*

The neutral sodium sulphite solution containing the ketone was rendered strongly alkaline and the ketone isolated in the usual manner. The ketone boiled at 230-231°/697mm. and was identified as *d-l.* piperitone by conversion into the  $\alpha$  and  $\beta$  semicarbazones melting at 225-227° and 174-178° respectively and the oxime melting at 117-118°.

The fraction which boiled above 140°/200mm. (29.8 per cent) was shaken with sodium carbonate solution which remove a trace of free acid (A) and then with dilute sodium hydroxide solution to remove the phenol (B). The residual oil was treated with alcoholic potassium hydroxide solution to hydrolyse the esters present, the neutral oil separated, the alkaline solution being reserved for further investigation (C). The oil was carefully fractionated under diminished pressure (29mm.) when the main fraction was found to distil at 168-180° and on redistillation boiled fairly constantly at 176-177°/31mm. This somewhat viscid oil evidently consisted of a sesquiterpene alcohol and had the following constants :— $D_{\frac{30^\circ}{30^\circ}}^3$  0.9674,  $N_D^{30^\circ}$  1.5034,  $[\alpha]_D^{30^\circ}$  +12.8°.

0.1148 gave 0.3458 CO<sub>2</sub> and 0.1138 H<sub>2</sub>O, C=82.2, H=11.0.

0.1296 gave 0.3885 CO<sub>2</sub> and 0.1306 H<sub>2</sub>O, C=81.8, H=11.2.

C<sub>16</sub>H<sub>24</sub>O requires C=81.8, H=10.9 per cent.

The sesquiterpene alcohol described by Roberts (loc. cit. p. 1470) would not appear to be identical with this alcohol since he obtained analytical results agreeing with the formula C<sub>15</sub> H<sub>26</sub> O. His alcohol

\*See footnote page 19.

boiled at 170-175°/21 mm. and had the following constants :— $D_{15}^{15} 0.9544$   $[\alpha]_D^{24} +10.48$ . In view, however, of the well-known difficulty of purifying substances of this nature too great reliance cannot be placed on these results.

From the fraction of the neutral oil which boiled below 168°/29mm. a small quantity of oil was obtained which had a rose like odour. It could not be obtained pure but since it yielded a ketone on oxidation with chromic acid it was evidently an alcohol, possibly identical with that described by Roberts. (loc. cit. p. 1469.)

The acid separated from the sodium carbonate solution *A* (see above) crystallised almost completely on keeping. After draining on porous porcelain it was recrystallised from methyl alcohol when it was found to melt at 61-62° and was identified as palmitic acid.

The sodium hydroxide solution *B* was washed with ether, the solution saturated with carbon dioxide, when a small quantity (0.2 per cent) of a semi-solid oil separated. The quantity was however insufficient for examination.

The alkaline solution *C* after removal of the alcohol was acidified and the liberated acids distilled in steam when a small quantity of a sparingly soluble oil passed over. The silver salt gave on analysis  $Ag=42.6$  per cent, whereas  $C_8H_{15}O_2$   $Ag$  requires  $Ag=43.0$  and  $C_{10}H_{19}O_2$   $Ag$  requires  $Ag=39.0$  per cent. The liquid acid was therefore in all probability a mixture of octoic and decoic acids.

## PART V.

**The Essential Oil from the seeds of *Zanthoxylum alatum*, Roxb.**

*Zanthoxylum alatum*, Roxb. occurs in the Outer Himalaya from the Indus eastwards ascending to 7000 feet; in the Khasi and Naga Hills; in the hills of Vizagapatam and Ganjam and in Burma.

The oil from the seeds of *Z. alatum* would not appear to have been investigated previously. An oil examined by Semmler (Berichte. 1911. 44. 2885.) and considered by him to have been derived from these seeds, would appear from the evidence afforded in Part VII of this series (see page 31) to have been derived from the seeds of *Z. Budrunga*.

The seeds from which the oil was distilled were kindly presented to the authors by Colonel C. R. Johnson of Abbottabad and the seeds were identified by Mr. R. S. Hole by a botanical examination of the plants from which they had been gathered. The authors wish to express their thanks to Colonel Johnson for his assistance.

The oil was found to consist almost entirely, over 85 per cent, of the hydrocarbon *l*- $\alpha$ -phellandrene which was identified by conversion into the nitrosite. A small quantity of linalol was also present and in addition an unidentified sesquiterpene. The oil would not appear to be of any economic value.

*Experimental.*

The oil used for the experiments described below was obtained by the distillation in steam at a pressure of 25 lbs. of the freshly ground seeds of *Z. alatum* from the Hazara district. The oil which was pale yellow in colour, was obtained in a yield of 1.5 per cent and had the following constants:— $D_{20}^{20}$  0.8482,  $N_D^{30}$  1.4715, saponification value 12.98, saponification value after acetylation 31.7, acid value 1.23.

A quantity of the oil was distilled under diminished pressure (100mm.) when the following fractions were obtained:—

No.	B. P.	Yield per cent.
I	108-120°	85.3
II	120-140°	5.5
III	140-180°	7.3

Fraction I. which had the following constants evidently consisted of a hydrocarbon :— $D_{30}^{30} 0.839$ ,  $N_D^{30} 1.4702$ ,  $[\alpha]_D^{30} -20.96^\circ$ . It was purified by distillation over sodium when it was found to boil very constantly at  $169.5-171.5^\circ/697\text{mm}$ . The following constants were observed for the pure hydrocarbon :— $D_{30}^{30} 0.8715$ ,  $N_D^{30} 1.4695$ ,  $[\alpha]_D^{30} -21.26^\circ$ . A careful examination showed that it consisted of practically pure *l*- $\alpha$ . phellandrene,  $\beta$ -phellandrene and dipentene being absent. The phellandrene nitrosite prepared in the usual manner decomposed at  $105^\circ$  and was separated into the two isomeric forms melting at  $105^\circ$  and  $113-114^\circ$ .

*Fractions II and III.*—These two fractions which were only obtained in small quantity were found to be free from phenols, ketones and aldehydes. They were combined and treated with an alcoholic potassium hydroxide solution to hydrolyse any esters present. The neutral oil was separated in the usual manner, the alkaline liquid being reserved for further examination (see below). On fractionation of the neutral oil under diminished pressure (200mm.) after a further quantity of the terpene had distilled over below  $140^\circ$ , a fraction was obtained which distilled fairly constantly between  $140-155^\circ$ . This fraction which was too small for further purification smelt strongly of linalol but all attempts to prepare the crystalline urethane were unsuccessful. On oxidation with chromic acid in acetic acid solution citral was evidently formed and was recognised by its characteristic smell and there can therefore be little doubt that this fraction consisted essentially of linalol.

A small quantity of a viscid oil distilled above  $155^\circ$  and consisted apparently of a sesquiterpene but it was too small in quantity for investigation.

The alkaline solution from which the linalol had been separated was evaporated on the water bath until free from alcohol and made acid with dilute sulphuric acid when a viscid oil separated. This was distilled over in steam and the volatile acid, which only passed over very slowly, made into the silver salt which was found to contain 36.8 per cent of silver a figure agreeing well with that required for the silver salt of undecylic acid ( $\text{Ag}=36.9$  per cent).

## PART VI.

**The Essential Oil from the Seeds of *Zanthoxylum acanthopodium* D.C.**

*Zanthoxylum acanthopodium* D. C. occurs in the Outer Himalaya, Kumaon to Sikkim, Khasi Hills, and Burma.

It has not unfortunately been possible to definitely identify botanically the species of *Zanthoxylum* to which the seeds used in this investigation belonged. The seeds, which were obtained from Gonda in the United Provinces, are stated to be imported from Sikkim. A botanical specimen obtained from Sikkim could not be identified but it is at present considered by Mr. R. S. Hole to resemble most closely *Z. Planispinum*, a Japanese variety. This question is being further investigated and it is hoped to obtain from Japan botanical specimens and seeds for investigation. A small sample of seeds obtained from Burma and definitely identified as derived from *Z. acanthopodium* yielded on distillation an oil which appeared to be identical with the one described in this paper. For the present therefore the seeds imported into Gonda from Sikkim are considered to be derived from *Z. acanthopodium*.

The oil from the seeds of *Z. acanthopodium* has been previously investigated (Schimmel Ber. 1900. 50., 1901. 62., 1911. 42.) and was found to contain dipentene, *d*-linalol, and methyl cinnamate. The authors can confirm the presence in the oil of these constituents and have in addition isolated *l*- $\alpha$ -phellandrene which would appear to be present in considerable quantity. The oil also contained a small amount of an aldehyde or ketone, cinnamic acid and a mixture of fatty acids consisting probably of caproic, caprylic, and oenanthic acids.

In view of the high linalol content of this oil it would appear to be likely to be of considerable economic value. Through the kindness of Professor W. H. Perkin, F. R. S. of the University of Oxford, a sample of the oil was valued in England and it was stated that it could probably be sold at about 6/- per lb.

*Experimental.*

The oil used in this investigation was obtained by the distillation in steam at a pressure of 20 lbs. of the freshly gathered seeds which prior to distillation were roughly ground. The oil which was obtained in a yield of 1.2 per cent had the following constants:— $D_{20}^{20}$  0.8837,  $N_D^{30}$  1.4746,  $[\alpha]_D^{30}$  +6.54°, saponification value 60.79, saponification value after acetylation 242.5, (this value was determined after



admixture with turpentine (Boulez. Bull. Soc. Chim. 1907. IV. (i) 117), acid value 5.5.

Preliminary examination having shown the presence in the oil of a trace of an aldehyde or ketone and of acids, a kilo of the oil was shaken with sodium hydrogen sulphite solution when a small quantity (5 grammes) of a crystalline bisulphite compound separated.\*

This was filtered off, the oil well washed with dilute sodium hydroxide solution (see below), dried and distilled under diminished pressure (47mm.) when the following fractions were obtained :—

No.	B. P.	Yield per cent.
I	100-110	20.1
II	110-120°	32.3
III	120-130°	20.3
IV	130-140°	7.8
V	140-170°	13.2
VI	Residue	1.3

After repeated refraction under diminished pressure (100mm.) the following fractions were ultimately obtained :—

No.	B. P.	Yield per cent.
I	112-115°	15.5
II	115-120°	4.5
III	120-129°	4.3
IV	129-132°	16.9
V	132-135°	23.6
VI	135-140°	18.9
VII	140-150°	3.2
VIII	130-150° /47mm.	13.0
IX	159-163° /47mm.	12.5

\* It was not found possible to isolate the ketone or aldehyde in a pure state. The semicarbazone was a mixture and after repeated crystallisation a small fraction was obtained in fine needles melting at about 180°. It was not identified.

*Fraction I.*—This fraction which evidently consisted of a hydrocarbon had the following constants :— $D_{30}^{30^{\circ}}$  0·8402,  $N_D^{30^{\circ}}$  1·4671,  $[\alpha]_D^{30^{\circ}}$  —0·98°. After repeated distillation over sodium it boiled almost constantly at 109°/100mm. and had the following constants :—

$$D_{30}^{30^{\circ}} 0\cdot8296, N_D^{30^{\circ}} 1\cdot4695, [\alpha]_D^{30^{\circ}} -5\cdot45^{\circ}.$$

0·0851 gave 0·2759 CO<sub>2</sub> and 0·0908 H<sub>2</sub>O, C=88·4, H=11·9.

C<sub>10</sub>H<sub>16</sub> requires C=88·2, H=11·8 per cent.

This oil was found to be a mixture of dipentene and *l.*— $\alpha$ . phellandrene. When dissolved in acetic acid and treated with bromine in the usual manner a copious precipitate of dipentene tetrabromide separated which after crystallisation from ethyl acetate melted at 124–125°. (Found Br.=70·1, calc. Br.=70·2 per cent.) The presence of phellandrene was shown by the formation of phellandrene nitrosite on treatment of the hydrocarbon by Wallach's method (Annalen. 1895, 287, 371). The yield of nitrosite was poor and after recrystallisation from a mixture of chloroform, alcohol and ether it was obtained in fine needles melting at 103–104°. In one experiment the melting point was raised to 107° and this specimen was evidently nearly pure *l.*— $\alpha$  phellandrene- $\alpha$ -nitrosite.  $\beta$  phellandrene did not appear to be present since no trace of ketone was formed on treatment with oxygen and exposure to sunlight.

*Fraction II.*—This fraction was nearly pure dipentene and gave on treatment with bromine an excellent yield of dipentene tetrabromide.

*Fraction III.*—This fraction consisted of a mixture of dipentene and *d*-linalol. They were identified by conversion into the tetrabromide and phenyl urethane respectively.

*Fractions IV, V, VI.*—These three fractions consisted of practically pure *d*-linalol as shown by the following analyses and constants :—

Fraction IV.  $D_{30}^{30^{\circ}}$  0·8563,  $N_D^{30^{\circ}}$  1·4604,  $[\alpha]_D^{30^{\circ}}$  +12·74°.

0·0854 gave 0·249% CO<sub>2</sub> and 0·0932 H<sub>2</sub>O, C=79·6, H=12·1.

C<sub>10</sub>H<sub>18</sub>O, requires C=77·9, H=11·7, per cent.

Fraction V.  $D_{30}^{30^{\circ}}$  0·8618,  $N_D^{30^{\circ}}$  1·4585,  $[\alpha]_D^{30^{\circ}}$  +14·54° per cent.

0·1012 gave 0·2974 CO<sub>2</sub> and 0·1054 H<sub>2</sub>O, C=77·5, H=11·6.

Fraction VI.  $D_{30}^{30^{\circ}}$  0·8647,  $N_D^{30^{\circ}}$  1·46,  $[\alpha]_D^{30^{\circ}}$  +13·82°.

0·1024 gave 0·2926 CO<sub>2</sub> and 0·1064 H<sub>2</sub>O, C=77·9, H=11·5.

On refractionation practically the whole boiled constantly at 150-152°/200mm. and gave the following results on analysis :—

0.0972 gave 0.279 CO<sub>2</sub> and 0.0999 H<sub>2</sub>O, C=78.2, H=11.4.

C<sub>10</sub>H<sub>18</sub>O, requires C=77.9, H=11.7 per cent.

The constants were found to agree well with those quoted for linalol :  $D_{30}^{30} 0.8596$ ,  $N_D^{30} 1.4581$ ,  $[\alpha]_D^{30} +12.69^\circ$ . The presence of *d*-linalol was confirmed by the preparation of the phenyl urethane melting at 64-65° and by its oxidation to citral, which was readily identified by conversion into citrylidene malonic acid melting at 191°, the melting point of which was unaltered on admixture with this acid obtained from another source. When treated with 5 per cent sulphuric acid the *d*-linalol gave an excellent yield of terpin hydrate.

*Fractions VII and VIII.*—These two fractions were found to be a mixture of *d*-linalol and methyl cinnamate. On treatment with alcoholic potassium hydroxide solution a sparingly soluble potassium salt separated which on decomposition yielded pure cinnamic acid. On addition of water to the filtrate from the potassium salt an oil separated which was found to distil constantly at 150—152°/200mm. and was identified as *d*-linalol. The alkaline solution, from which the *d*-linalol had been separated, gave on acidification a further quantity of cinnamic acid contaminated with a small quantity of an oily fatty acid which was not obtained in sufficient quantity for investigation. These two fractions contained approximately 60 per cent. of *d*-linalol.

*Fraction IX.*—This fraction which crystallised on keeping in the cold, gave on analysis figures agreeing fairly well with those required for methyl cinnamate.

0.1283 gave 0.3514 CO<sub>2</sub> and 0.0846 H<sub>2</sub>O, C=74.7, H=7.0.

C<sub>10</sub>H<sub>18</sub>O<sub>2</sub> requires C=74.1, H=6.2 per cent.

A portion of the oil was therefore hydrolysed with methyl alcoholic potassium hydroxide solution when a sparingly soluble potassium salt separated. This was found to consist of potassium cinnamate, the cinnamic acid therefrom melting at 133°.

0.1615 gave 4334 CO<sub>2</sub> and 0.0787 H<sub>2</sub>O, C=73.1, H=5.4.

C<sub>9</sub>H<sub>8</sub>O<sub>2</sub> requires C=73.0, H=5.4 per cent.

A further quantity of cinnamic acid was isolated from the alkaline filtrate after removal of the alcohol and no other acid appeared to be present. A special test confirmed the presence of methyl alcohol in the ester.

*Acids present in the oil.*

The sodium hydroxide solution with which the original oil had been washed (see above), was saturated with carbon dioxide and repeatedly extracted with ether. On evaporation of the ether an oil (12 grammes) remained which on cooling partially solidified. As the oil appeared to consist of an acid and not as had been expected of a phenol, it was dissolved in a slight excess of ammonia and treated with a solution of calcium chloride when a sparingly soluble calcium salt separated. This was collected, washed with alcohol and decomposed with dilute hydrochloric acid, when an oil separated which rapidly solidified. After draining on porous porcelain, the solid was recrystallised from methyl alcohol when it was obtained in glistening leaflets melting at 62-63° and evidently consisted of palmitic acid since the melting point was not altered on admixture with an equal quantity of this acid from another source. The silver salt was analysed. (Found Ag=29·9, calc. Ag=29·7 per cent.) The filtrate from the sparingly soluble calcium salt gave on acidification a trace of an oily acid which was not further investigated.

The sodium carbonate solution from which the palmitic acid had been separated was acidified when an oil was obtained which smelt strongly of the higher fatty acids. On standing it deposited a small quantity of a crystalline solid which after crystallisation from water melted at 133° and was identified as cinnamic acid. The oily acid (1·2 grammes) was esterified with alcohol and sulphuric acid and resulting esters distilled when the following fractions were collected :—160—170°, 170—180°, 180—200°, 200—250°, 250—270°. The fraction boiling at 250—270° (1·3 grammes) consisted essentially of ethyl cinnamate since on hydrolysis cinnamic acid contaminated with a trace of an oily acid was obtained. The remaining fractions, since they were insufficient in quantity for purification, were hydrolysed with barium hydroxide solution, the excess of barium removed by carbon dioxide, and the soluble barium salts converted into the silver salts which were analysed.

<i>B. P.</i>	<i>Ag. per cent.</i>
160—170° . . . . .	47·2
170—180° . . . . .	47·4
180—200° . . . . .	46·2
200—250° . . . . .	45·2

From these analyses it appears likely that the fractions boiling between 160—180° consisted essentially of ethyl capronate (B. P. 166·6), since the silver salt of capronic acid requires Ag=48·4 per cent. The remaining two fractions possibly consisted of a mixture of ethyl oenanthate (B. P. 187°) and ethyl caprylate (B. P. 205°) since the silver salts, these acids require Ag=45·5 and 43·0 per cent. respectively.



## PART VII.

### The Essential Oil from the Seeds of *Zanthoxylum Budrunga*, Wall.

It would appear to be very doubtful if the two species *Zanthoxylum Rhetsa* D. C. and *Zanthoxylum Budrunga*, Wall. are in reality different from one another. The distribution of *Z. Rhetsa*, D. C. (including *Z. Budrunga*, Wall.) is fairly extensive since it is found on the Eastern and Western Ghats, in Bihar and Orissa, Bengal, Assam and Burma.

The seeds used in this investigation were obtained from Kanara and the plant from which the seeds were derived was definitely identified by Mr. R. S. Hole as being *Z. Budrunga*, Wall. It will be a matter for future investigation to determine whether the so-called *Z. Rhetsa* really exists as a separate species and whether a different oil can be obtained from the seeds.

The seeds find a local use as a condiment but so far as the authors are aware the oil has not found any commercial application.

Some years ago Semmler (Berichte. 1911. 44. 2885.) examined an oil which had been placed at his disposal by Messrs. Schimmel and Co. and which was stated to have been distilled from the seeds of *Z. alatum*. From this oil he isolated (1) a terpene to which he gave the name xanthoxylene, although he pointed out that it was in all probability identical with *l*-sabinene, (2) a small quantity of an aldehyde probably cuminaldehyde, and (3) a ketone which was identified as dimethoxy phloroacetophenone. As was pointed out in part V. of this series (page 23), the oil from *Z. alatum* was found to have quite different properties and to consist almost entirely of phellandrene.

The oil obtained by the authors from the seeds of *Z. Budrunga* would, however, appear to resemble in its properties the oil examined by Semmler. Two samples of seeds were used, namely, young seeds and mature seeds and in Table I are given the constants of the oils obtained together with the constants found by Semmler for his oil.

TABLE I.

—	Oil from young seeds.	Oil from ripe seeds.	Semmler's oil.
D $\frac{30^\circ}{30^\circ}$ . . .	0.8532	0.8426	D $20^\circ$ 0.8632
N $\frac{30^\circ}{D}$ . . .	1.469	1.4656	N $\frac{20^\circ}{D}$ 1.4795
$[\alpha]_D^{30^\circ}$ . . .	-37.7°	-29.55°	-23°
Acid value	0.18	0.3	...
Saponification value	3.05	8.5	...
Saponification value after acetylation	24.21	56.5	...

On fractionation of the oil under diminished pressure (see page 34) it was found to consist almost entirely of a hydrocarbon  $C_{10}H_{16}$ . This hydrocarbon would appear to be identical with Semmler's "xanthoxylene." The constants of the hydrocarbon obtained by the authors are given in Table II compared with those of Semmler's hydrocarbon whilst the constants of *d*-sabinene are also given.

TABLE II.

	Terpene (young seeds).	Terpene (ripe seeds).	Semmler's terpene.	<i>d</i> -sabinene.
B. P.	161.5-163/705mm.	162.5-163.5/705mm.	50-60°/9mm	163-165°
D $\frac{30^\circ}{30^\circ}$ .	0.8407	0.8399	D $20^\circ$ 0.84	0.842
N $\frac{30^\circ}{D}$ .	1.465	1.4655	N $\frac{20^\circ}{D}$ 1.4745	1.4678
$[\alpha]_D^{30^\circ}$ .	-46.19°	-34.53°	-26°	+80.71°
M <sub>D</sub>	44.61	44.80	...	44.88

As was mentioned above Semmler considered that his hydrocarbon, which was obviously identical with that obtained by the authors, to be

*l*-sabinene. Owing, however, to the small amount of material at his disposal he was not able to confirm this view. The authors have been able to show that the terpene present in the seeds of *Z. Budrunga* is undoubtedly *l*-sabinene. On oxidation with potassium permanganate in alkaline solution it yielded an acid  $C_{10}H_{16}O_3$  which yielded a sparingly soluble sodium salt and melted at  $55-57^\circ$ , which is the melting point of sabinenic acid, the acid was strongly laevo-rotatory. On treatment with hydrogen chloride in acetic acid solution terpinene dihydrochloride melting at  $52^\circ$  was formed, whilst when shaken with dilute sulphuric acid 1 : 4-terpin melting at  $137^\circ$  was obtained. The formation of these derivatives leaves little doubt of the identity of the terpene with *l*-sabinene, a terpene which has not previously been found in nature.\*

It was mentioned above that Semmler also showed the presence of an aldehyde and of dimethoxy phloroacetophenone in his oil. Neither of these constituents were present in the oil examined by the authors. In addition to *l*-sabinene, a small quantity of a hydrocarbon having a higher boiling point was separated which yielded a nitrosite melting at  $155^\circ$  and was evidently terpinene. The presence of an alcohol was also indicated but it was not found possible to identify it.

In the authors' opinion there would appear to be little doubt that the oil examined by Semmler was derived from the seeds of *Z. Budrunga*. It is possible that dimethoxy phloroacetophenone may be present in the seeds at a different stage in their development, whilst the cuminaldehyde (which was only found in small quantity) may have owed its origin to the oxidation of sabinene or terpinene.

#### *Experimental.*

The oil which was obtained from the roughly ground seeds by distillation in steam (pressure 20 lbs.) was almost colourless and possessed a pleasant and characteristic odour. The yield of oil from the seeds was much higher in the case of the ripe seeds (3 per cent) than in the case of the young seeds (0.6 per cent). The constants of the two samples of oil have already been given in Table I. Both oils on distillation yielded approximately the same results although the hydrocarbon from the young seeds was somewhat more highly laevo-rotatory and

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\*Agnew and Croad (Analyst 1912. 295) isolated *l*-sabinene from oil of savi. The authors have not been able to consult the original paper and the published abstracts do not quote the constants of the terpene separated by them. According to Wallach (Berichte 1907. 40. 587) and Semmler (Berichte 1900. 33. 1464) oil of savi contains *d*-sabinene.

as the oil from the ripe seeds was more thoroughly investigated the details given below refer to this oil.

A quantity of the oil was washed with dilute sodium carbonate solution to remove the free acids, with dilute sodium hydroxide solution (5 per cent) to remove any phenols and finally, after drying over potassium carbonate, distilled under diminished pressure (100mm.) when the following fractions were obtained :—

No.	B. P.	Yield per cent.	D $\frac{30^\circ}{30^\circ}$	N $\frac{30^\circ}{D}$	$[\alpha]_D^{30^\circ}$
I	98—110° . .	84	0.8389	1.4654	— 30.82°
II	110—120° . .	8.8	0.8422	1.4675	— 21.34°
III	120—180° . .	4.6	0.8712	1.4731	— 18.18°
IV	Free acids and loss .	2.6	...	...	...

On refractionation the following fractions were ultimately obtained :—

No.	B. P.	Yield per cent.
I	95—110°	90.8
II	110—120°	1.8
III	120—150°	1.0
IV	150—180°	2.0
V	above 180°	0.8

*Fraction I* was redistilled using a four pear Young still head when it was found to distil very constantly at 159.5—165°/705mm. and on distillation over sodium was found to boil at 162.5—163.5°/705mm. The constants of *l*-sabinene have been given in Table II.

#### *Oxidation to l-Sabinenic Acid.*

The terpene (25 grammes) was oxidised with potassium permanganate under the conditions described by Wallach (Annalen. 1908, 359. 265), and the sparingly soluble sodium salt purified by recrystallisation from water. On acidification the pure salt deposited an oil which slowly solidified and was recrystallised from hot water from which

it separated in leaflets melting at 55—57°. In methyl alcohol solution it had  $[\alpha]_D^{30} -86.25^\circ$ .

0.1007 gave 0.239 CO<sub>2</sub> and 0.0776 H<sub>2</sub>O, C=64.7, H=8.5.

C<sub>10</sub>H<sub>16</sub>O<sub>3</sub> requires C=65.2, H=8.7 per cent.

When this acid was oxidised in acid solution with potassium permanganate a ketone was formed which was probably *l*-sabina ketone but it has not up to the present been examined.

#### *Formation of Terpinene Dihydrochloride.*

*l*-Sabinene was dissolved in excess of acetic acid and the well cooled solution saturated with hydrogen chloride. After standing overnight the solution was mixed with ice when a heavy oil separated which immediately crystallised. The solid was collected, drained on porous porcelain to remove a little adherent oil, and recrystallised from dilute alcohol when it was obtained in beautiful leaflets which melted at 51—52° and was found to be identical with terpinene dihydrochloride obtained from another source.

#### *Formation of 1 : 4 Terpin.*

*l*-Sabinene (10 grammes) was mixed with dilute sulphuric acid (5 per cent) (200cc.) and the mixture shaken on the machine for some days. After saturating the acid solution with ammonium sulphate, the reaction product was extracted with ether, the ether dried and evaporated and the residual oil distilled in steam to remove a little unchanged terpene and any terpineol which had been formed. The residue from the steam distillate was taken up with ether, the ether dried and evaporated when a viscid oil remained which rapidly solidified. After draining on porous porcelain it was recrystallised from a mixture of ethyl acetate and light petroleum when it was obtained in glistening leaflets melting at 135—136°. It was identified as 1 : 4-terpin.

0.1054 gave 0.3694 CO<sub>2</sub> and 0.1094 H<sub>2</sub>O, C=69.7, H=11.5

C<sub>10</sub>H<sub>20</sub>O<sub>2</sub> requires C=69.8, H=11.6 per cent.

*Fractions II and III.* These two fractions which consisted essentially of *l*-sabinene were carefully tested for the presence of other hydrocarbons. Dipentene (or limonene) was absent from both fractions but from Fraction III (B.P. 120—150°/100mm.) a small quantity of a crystalline nitrosite was obtained which after crystallisation from alcohol melted at 155° and was probably terpinene nitrosite which is stated to melt at this temperature.



*Fractions IV and V.*—These two fractions were combined and boiled with a solution of potassium hydroxide in alcohol to hydrolyse any esters present. The oil recovered from this treatment was distilled at 100mm. when two main fractions were obtained boiling at 110—140° and 160—185°. The first of these fractions was found to contain terpinene (identified by the nitrosite), whilst the second fraction which smelt strongly of terpineol contained a small quantity of an alcohol which was not identified.

*Free Acids.*

The sodium carbonate extract of the original oil was washed with ether to remove adhering oil and acidified when a liquid acid separated which rapidly solidified. The solid was collected, drained on porous porcelain, and recrystallised from methyl alcohol when it was obtained as leaflets which melted at 62-63° and was identified as palmitic acid.

(Received 18th April 1922.)

Forest Research Institute and College,  
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VOL. IX

PART V

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**Further Experiments in the Air-Seasoning of Indian  
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as to Seasoning Methods**

By

**C. V. SWEET, B.S., M.F.,**

Officer-in-Charge Section of Scientific Forest Research Institute, Dehra Dun  
(Late in Charge of the Section of Timber Physics, U. S. Forest  
Products Laboratory, Madison, Wisconsin.)

with a chapter on

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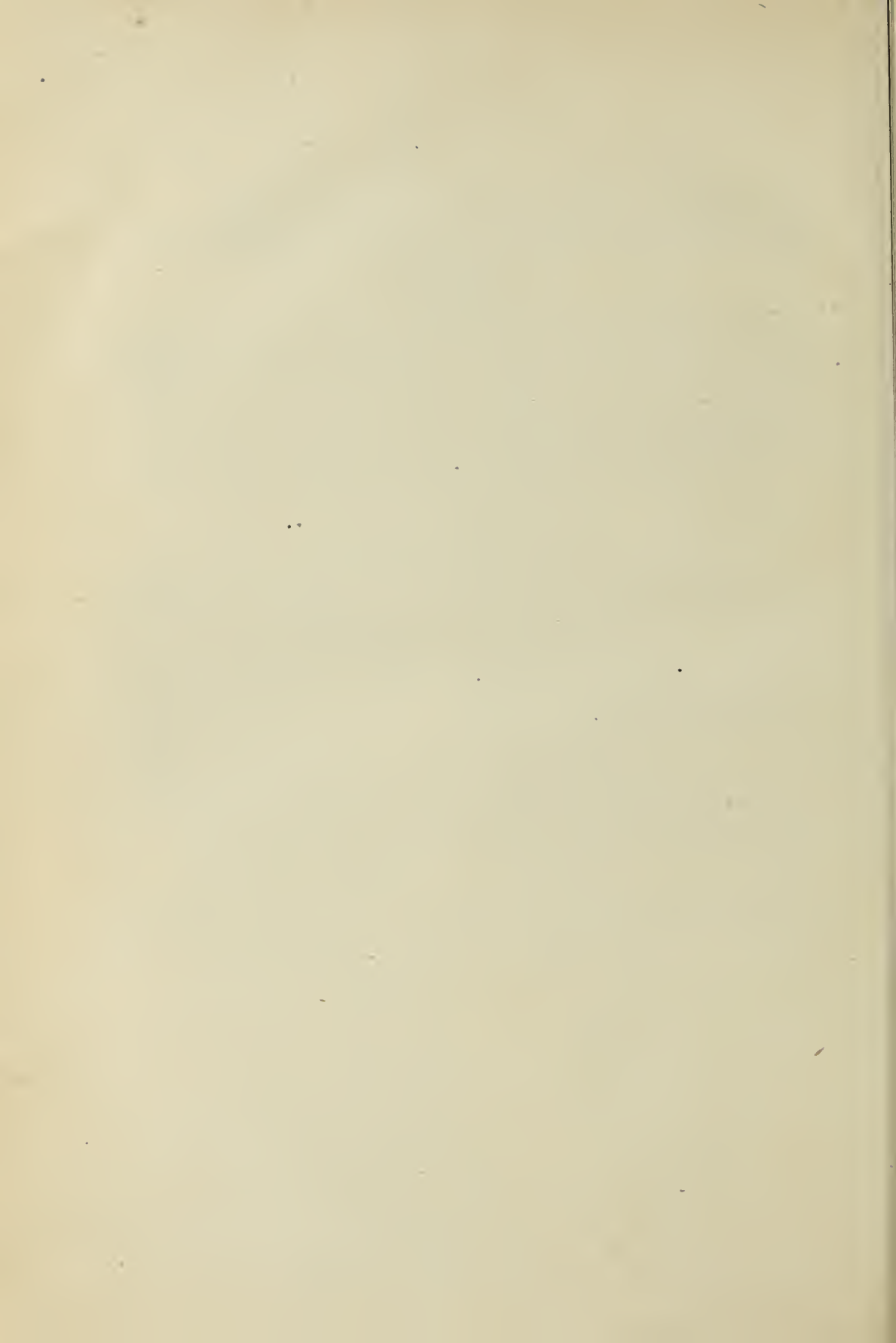
## PREFACE.

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The protection provided by these sheds is sufficient for this locality in view of the moist climate and the natural protection afforded by the surrounding hills and heavy forest.

Method of Stacking and Sheltering the Timber for Air Seasoning Experiments, Coorg.





## INTRODUCTION.

IT is becoming increasingly evident to those interested in the utilization of Indian timbers that most deliberate attention must be given to the seasoning process. Whether we look at the problem from the standpoint of the forest officer or timber firm anxious to win recognition for the properties and merits of species but slightly known to the wood-using trades, or whether from the point of view of an industry desiring to find a suitable wood for a special product, the conclusion reached is invariably the same—the importance attached to the seasoning process cannot be over-emphasized. It is true that for some purposes green timber may be used with as satisfactory results as seasoned wood. In such cases, which are relatively few in number, the properties of timber may be based on the unseasoned condition. But for the majority of uses the properties of wood depend to a very large degree upon the seasoning, and it is only through proper seasoning that the most desirable characteristics of the wood are brought into effect.

Seasoning is known, even by the layman, to be an essential operation between the process of cutting the logs into lumber and their final use, but the exact significance of the operation and the possibilities for good or bad results attending the process are not generally recognized even by those who are most directly interested. Too often the seasoning is grossly neglected either through irresponsibility or ignorance. Inasmuch as it is impossible to determine the degree of seasoning by mere superficial examination, unless an actual test is taken, it is necessary to accept the word of some one to a large extent. Responsibility is therefore easily shifted from one to another and the results of neglect often are not apparent until after considerable time has elapsed. When timber which is said to be thoroughly seasoned is made up into the finished product and later cracks, shrinks, and falls apart, the fault may be laid to any of the agencies handling the wood or to the climate, but more often to the wood itself. It happens too frequently that an unknown wood is tested under unknown conditions of seasoning and is given an unsatisfactory and unfair judgment.

Green, unseasoned wood is used with less hesitation and apology in India than in most countries where the timbers are less refractory and the climatic conditions much less severe. The absence of timber yards in which converted timber is held for air seasoning is specially striking and significant of the fact that thorough seasoning before use is seldom accomplished. In the place of timber yards we see log depôts storing quantities of logs, many of which depreciate much more rapidly than they season. The practice of holding logs rather than converted timber for seasoning is due perhaps as much to the lack of appreciation of the damage that occurs in most logs during storage and of the little seasoning that actually takes place as to the

extraction and milling methods which make prompt conversion very difficult at the present time.

It is no uncommon sight to see country-made vehicles and furniture being made up of wood but freshly sawn from the logs. And this practice is not limited to those of meagre opportunity or of narrow vision. Some of the finest public buildings in India are finished with expensive, but unseasoned, woodwork with the result that within a few months after completion the work becomes severely discredited and at best but a striking testimony of the real economy of using thoroughly seasoned wood, even though its initial cost is greater than that of green wood.

The problem in this country is more complicated than elsewhere because of the climatic extremes to which wood is subjected from season to season or upon shipment from one region to another. In efforts to insure that woodwork or timber withstands such extremes three cardinal principles must be borne in mind: first, although seasoning will not eliminate all difficulty with the expansion and contraction of wood, dry wood is better able to withstand climatic extremes than green wood: second, timber must be seasoned to an extent dependent upon the atmospheric conditions under which it is to be used rather than upon those of the locality in which the seasoning is accomplished: and third, for close fitting woodwork the degree of seasoning, *i.e.*, the moisture content, at the time of cutting to finished dimensions must be known with reference to the extremes to which it will be subjected in service so that all possible allowance may be made in the dimensions of the parts and the form of construction. A critical question to be raised in this connection is "To what extent will the seasoning process, when properly carried out, eliminate the difficulties encountered with woodwork in India?" The answer must be "Although it is only one of several factors to be taken into consideration, seasoning is of basic importance." Stable woodwork involves, in addition to careful seasoning, (1) the selection of the species that have the least shrinkage and tendency to warp and twist with a given change in atmospheric conditions, (2) the application of an effective coating such as varnish, paint, or oil to the finished article in order to retard the rate of change in moisture in the wood and thus prevent periodic, sudden swelling and shrinking, and (3) the careful design of wooden parts so that the members may expand and contract freely within prescribed channels according to the demands of the atmosphere and without ruining the part or the whole. These are considerations involving detailed investigation and warranting special attention and should be taken up simultaneously with the problems of seasoning. The study of these factors leads to one of the most intricate problems connected with our knowledge of wood, namely, the hygroscopic relation between wood and the atmosphere, with reference to the behaviour of wood. The success of our efforts to eliminate the difficulties with woodwork

in India will be in direct proportion to our understanding of this relation.

As to the necessity of seasoning there can be no argument nor occasion for further discussion here. The point of importance is how the seasoning should be accomplished. Little is known except for a few species as to the seasoning characteristics of Indian timbers, the best method of handling them after cutting, and the forms of depreciation to which they are especially liable before they are ready for use. The pressing need of the moment is to initiate the practice of adequate seasoning before the timber is put to use.

There is little question but that the most effective and the ultimate solution of many of the timber seasoning problems in India lies in the prompt conversion of the logs followed by artificial drying in seasoning kilns. But this does not mean that radical improvement can come only with kilns. Although there are several instances at present where the installation of kilns is the most feasible solution of the problems at hand and where the advantages would be most pronounced, nevertheless, it is believed that sound policy involves the immediate acceptance of the necessity of thorough air-seasoning as the standard practice to be departed from only in special cases after a careful analysis of local conditions. This has been the line of development in Europe and America. In spite of the fact that the lumber producers in those countries are now rather rapidly turning from air-seasoning to kiln-seasoning, it is the writer's opinion that the seasoning practice in India may well follow along the high points of the lines of development elsewhere, at least until the advantages of proper seasoning are generally more appreciated.

Regardless of whether this becomes the accepted policy for general development in India, in the absence of seasoning kilns, immediate requirements can best be met by prompt conversion (except in special cases) at the most favourable season of the year, followed by careful stacking in specially provided seasoning sheds.

Too often natural seasoning means slipshod methods of stacking the lumber in the open exposed to sun, wind, and rain, and the ravages of insects and fungi; but there is no reason why this should be the case. Really satisfactory methods involve consideration of the advantages for various species of such methods of treatment as girdling, green conversion, water seasoning, and seasoning in the log; the rate of seasoning and the extent required under various conditions; the amount and kind of protection from the elements that the various species require; the time of year that the trees are felled and converted, and the care of the logs prior to conversion so as to protect them against splitting and the attack of insects and fungi. Such factors are of fundamental importance and the problems involved, even for any one species, are by no means easy of solution except by careful study.

The scheme of operations for the study covered by this Record included the investigation of these items as affecting 53 species in 8 provinces and 15 divisions. But with the staff and facilities available only a start has been made so that few of the questions raised can be answered definitely or finally at this time. At the conclusion of this study, which must be regarded as but mere preliminary work, we are able to narrow attention on to points which are of the greatest importance and to plan for more comprehensive work later.

The pressing need of an answer to some of the points raised justifies opinions and recommendations somewhat beyond the scope of the experiments as carried out so that this note includes somewhat more than the actual findings of the study. Some of the data and recommendations are based on the previous experience of the writer in America and on general observation of conditions in India.

Many of the conclusions arrived at are merely tentative, and are given only for guidance until more reliable deductions can be drawn. This is particularly the case in connection with the attempts to classify the different kinds of wood according to their particular characteristics and requirements. The classifications are a result of collaboration with the Forest Economist, the Forest Entomologist, and other research officers at Dehra Dun, but it must be emphasized that the data are merely the best available at the present time and are not to be regarded as final or conclusive.



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## Further Experiments in the Air-Seasoning of Indian Timbers and General Recommendations as to Seasoning Methods

BY

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### CHAPTER I.

#### . Previous Work in the Seasoning of Indian Timbers.

The investigation into approved methods of natural seasoning was started by the Forest Economist in 1914, and the results of the first phase of the work were published in *Indian Forest Records Volume VII, Part I. Preliminary Note on the Seasoning of some Indian Timbers by Natural Methods*, R. S. Pearson. Up to the time the investigation was started little attention had been given to the subject of controlling the seasoning except by following more or less blindly the time-honoured methods of the country. As to the actual effectiveness of the various methods used in different regions and by various firms, but little was known. There was not even a standard, generally-approved practice in common use, or a definite consensus of opinion as to what was correct or incorrect so that it was necessary to start with fundamentals and gather data concerning all of the methods in use by forest officers, timber firms, and sawmill managers.



The scheme of operations included study of the following methods and practices:—

- (1) Seasoning in the log on land and in water followed by conversion and subsequent seasoning.
- (2) Seasoning in the standing trees girdled for various periods, then felled, converted, and subjected to further seasoning.
- (3) Seasoning of timber converted from green logs and piled on land and in water for various periods.
- (4) Stacking of timber under cover and in the open.
- (5) Felling trees at different seasons of the year.
- (6) Coating ends of logs with various compounds to prevent splitting.
- (7) Removing bark from logs to decrease damage by insects.

Thirty-three species were subjected to test in six provinces typical of the various climatic extremes of British India. Analysis of the results of the preliminary work is unnecessary in this report inasmuch as the data have already been dealt with previously, but the two notes may well be studied together. It is quite to the point to emphasize in passing that as a result of the first study it was concluded that about 94 per cent. of the species dealt with should be seasoned either by girdling or by the conversion of green logs, with or without subsequent immersion in water, and that seasoning in the log gave good results with only a few species. It was found that protection against the sun and rain was essential both for soft woods and hard woods in order to eliminate the cracking and decay. The effectiveness of coating the ends of logs with a moisture-resistant material varied with the species. In some cases cracking was eliminated or reduced, while in others severe splitting occurred in spite of the end-coating. In general, the removal of the bark from logs held for seasoning reduced the damage done by insects, but increased the amount of cracking. The benefits derived from this practice depended to a large extent upon the species—whether the wood was more susceptible to damage by cracking or by insects. No definite conclusions were arrived at as regards the effect of the time of cutting upon the ultimate seasoning of the timber.

## CHAPTER II.

## Method of Conducting Present Series of Experiments.

The experience gained in carrying out the original series of experiments clearly indicated the necessity of simplifying the scheme for further work so that more attention could be given to the things of fundamental importance, leaving the finer points for more intensive study. Moreover, the conclusions as regards some questions, for example, the necessity of sheltering the timber during seasoning, were sufficiently definite to make further tests unnecessary. In the second and present series the tests were reduced to four main experiments, namely:

- (1) Natural seasoning in the log under cover for 18 months followed by conversion and stacking for 6 months.
- (2) Green conversion and stacking for 2 years.
- (3) Green conversion followed by water seasoning for 3 months and stacking for 21 months.
- (4) Girdling for 12—18 months followed by conversion and stacking for 6—12 months.

Each of the following species was subjected to the four methods of seasoning in the localities noted:—

Species.	Division.	Province.
<i>Litsæa polyantha</i> . . .	Bura . . .	Bengal.
<i>Stereospermum chelonoides</i> . . .		
<i>Dichopsis polyantha</i> . . .	Cox's Bazar . . .	
<i>Drimycarpus racemosus</i> . . .		
<i>Eugenia operculata</i> . . .		
<i>Acer Campbellii</i> . . .	Darjeeling . . .	
<i>Acrocarpus fraxinifolius</i> . . .	Kalimpong . . .	
<i>Ptereospermum acerifolium</i> . . .		
<i>Sterculia villosa</i> . . .		
<i>Tetrameles nudiflora</i> . . .		
<i>Anogeissus acuminata</i> . . .	Porahat . . .	Bihar and Orissa.
<i>Boswellia serrata</i> . . .		

Species.	Division.	Province.	
<i>Eugenia Jambolana</i> . . . .	Sambalpur . . . .	Bihar and Orissa.	
<i>Soymida febrifuga</i> . . . .			
<i>Anogeissus latifolia</i> . . . .	South Chanda . . . .	Central Provinces.	
<i>Boswellia serrata</i> . . . .			
<i>Careya arborea</i> . . . .			
<i>Chloroxylon Swietenia</i> . . . .			
<i>Cleistanthus collinus</i> . . . .			
<i>Grewia tiliaefolia</i> . . . .			
<i>Hardwickia binata</i> . . . .			
<i>Odina Wodier</i> . . . .			
<i>Schrebera swietenoides</i> . . . .			
<i>Soymida febrifuga</i> . . . .			
<i>Artocarpus hirsuta</i> . . . .	... . . . .	Coorg.	
<i>Calophyllum tomentosum</i> . . . .			
<i>Calophyllum Wightianum</i> . . . .			
<i>Dichopsis elliptica</i> . . . .			
<i>Dipterocarpus turbinatus</i> . . . .			
<i>Dysoxylum glandulosum</i> . . . .			
<i>Hardwickia pinnata</i> . . . .			
<i>Hopea parviflora</i> . . . .			
<i>Vateria indica</i> . . . .			
<i>Alstonia scholaris</i> . . . .	Wynaad . . . .	Madras.	
<i>Ficus asperima</i> . . . .			
<i>Vateria indica</i> . . . .	South Mangalore . . . .		
<i>Eugenia gardneri</i> . . . .			
<i>Hardwickia pinnata</i> . . . .			
<i>Hopea parviflora</i> . . . .			
<i>Hopea Wightiana</i> . . . .	Ganjam . . . .		
<i>Bursera serrata</i> . . . .			

Species.	Division.	Province.
<i>Careya arborea</i> . . . .	Ganjam . .	Madras.
<i>Garuga pinnata</i> . . . .		
<i>Soyimida febrifuga</i> . . . .		
<i>Sterculia urens</i> . . . .		
<i>Fraxinus floribunda</i> . . . .	Hazara . .	North-West Frontier Province.
<i>Juglans regia</i> . . . .		
<i>Albizzia stipulata</i> . . . .	Kangra . .	Punjab.
<i>Melia Azedarach</i> . . . .	Lahore . .	
<i>Aegle Marmelos</i> . . . .	Gonda . .	United Provinces.
<i>Anogeissus latifolia</i> . . . .		
<i>Anogeissus pendula</i> . . . .		
<i>Careya arborea</i> . . . .		
<i>Cassia Fistula</i> . . . .		
<i>Eugenia Jambolana</i> . . . .		
<i>Garuga pinnata</i> . . . .		
<i>Gmelina arborea</i> . . . .		
<i>Grewia tiliacifolia</i> . . . .		
<i>Holarrhena antidysentrica</i> . . . .		
<i>Holoptelea integrifolia</i> . . . .		
<i>Hymenodictyon excelsum</i> . . . .		
<i>Phyllanthus Emblica</i> . . . .		
<i>Saccopetalum tomentosum</i> . . . .		
<i>Stereospermum suaveolens</i> . . . .		
<i>Trewia nudiflora</i> . . . .		

In conducting experiments of this nature in various regions of the country it was necessary that a portion of the work be carried out by local forest officers. The general outline was prepared by the Forest Economist at Dehra Dun and instructions (vide Appendix II) were issued so that the various operations should be done more or less uniformly in the different divisions.

(i) PREPARATION OF MATERIAL AND LAYOUT OF EXPERIMENTS

Six logs of each species were selected for each experiment. Thus the material from 24 logs of each species was under test. Three of the six logs were converted radially and three tangentially according to general cutting diagrams furnished by the Forest Economist. Part of the material was sawn into boards and part into scantlings, and half of the boards thus converted were piled horizontally and half vertically. All of the scantlings were piled horizontally.

The actual methods of stacking the converted material and the kind of protection against the elements that was provided in each case are of considerable significance in the analysis of the results obtained, but a detailed description of each experiment in this note would be profitless. In general, the horizontally piled timber was stacked in small piles, whose width was that of the widest boards, upon rough uneven timber foundations. Odd bits of wood were used as crossers or battens between the pieces. The material from each log was piled by itself with the result that there was a very free circulation of air through the piles and around each piece, and no appreciable weight bearing upon the individual pieces to prevent them from warping and twisting freely. The vertically piled boards were piled on edge obliquely against a framework consisting of a horizontal pole supported 4 or 5 feet above the ground. The timber thus piled was covered by a thatch roof which served to keep off the rain and some of the sun. However, there was no protection whatever at the sides to break the winds or to keep the sun from shining for a portion of each day upon the timber near the outside.

The number of boards and scantlings of each species seasoned by each method, the dates of carrying out the various operations, and the thickness of the timber are shown in Appendix I.

(ii) FINAL INSPECTION OF TIMBER.

The final inspection upon which the conclusions are based was carried out as far as possible by research officers from the Forest Economist's branch, although in certain cases it was necessary to call upon the local forest officers for this inspection. At the time of final inspection each piece of timber was examined carefully for defects attending or attributable to the seasoning and the results were recorded on a specially prepared form opposite the number of the piece. The defects thus recorded against all the pieces under test were analyzed and averaged as described later on for purpose of summary and conclusion. In addition to the detailed inspection, all of the pieces of each species were laid out on the ground in piles according to the method of seasoning and a comparison drawn based on the general appearance and outstanding characteristics of the group as a whole.



## (iii) DEFINITION OF SEASONING DEFECTS AS USED AT FINAL INSPECTION.

For the purpose of the inspection the defects attending the seasoning as they appeared in the converted timber were taken as follows:—

*Surface Crack* (sometimes called “sun cracking”)—A rupture in and through the surface usually across the annual growth rings; caused by more rapid drying from the surface than from the inside of the piece.

*Split*.—Complete separation of the fibres with the grain starting from the end of the piece and extending toward the centre; caused by more rapid drying from the end sections than from the other surfaces.

*Shake*.—Complete separation of the fibres either with or across the growth rings resembling cracks and splits except that the cause as it appears in the converted timber is plainly attributable to an inherent weakness or an original defect in the wood rather than the result of unequal drying. Shake is aggravated by the seasoning, but it is present in the wood before seasoning begins.

*Warp*.—Curvature across the width of a piece of timber as detected by laying a straight edge across the broad surface from edge to edge. Warp is caused by unequal shrinkage or expansion across the grain, due either to the structure of the wood, method of sawing, or to uneven drying, or a combination of the three.

The term is commonly used in this connection to indicate curvature in any direction or plane, but for the purposes of this study, its application has been limited as described above.

*Cup*.—Curvature along the length of a piece as detected by laying a straight edge along the broad surface from end to end. Cup is caused by unequal longitudinal shrinkage or expansion due to the structure of the wood, or uneven drying, but more often to some mechanical effect such as improper support in piling.

*Twist*.—Curvature both across the width and along the length of a piece combining the effects of warp and cup, usually resulting from the seasoning of wood with interlocked grain or from uneven piling.

Both the terms *twist* and *cup* denote conditions which are usually included under the general term *warp*.

*Spring*.—Curvature along the length of a piece as detected by laying a straight edge along one edge from end to end. Spring is caused by unequal longitudinal shrinkage, particularly as between the heartwood and sapwood in quarter sawn boards.

*Decay*.—Breaking down of the wood fibres under the action of fungi as shown by actual disintegration or the characteristic lifeless or punky appearance, or the presence of dark or black lines.

*Mould*.—Superficial growth of the mycelium of certain groups of fungi upon the surface of the wood. Although these moulds as a rule

do not penetrate the wood or cause actual decay, they usually accompany and cover the growth of wood destroying fungi and are of significance in that the conditions favourable to the growth of the one are also conducive to the growth of the other.

*Discolouration.*—A variation from the normal colour of the wood caused by a chemical change due to oxidation, or the growth of fungi or bacteria on the surface of the wood or penetrating the interior.

*Insects.*—The boring, pitting, or further destruction of the wood by the action of insects.

#### (iv) DETERMINATION OF DEGREE OF SEASONING.

As a further and very important criterion of the seasoning, moisture tests were taken of representative pieces from each experiment and species. The moisture content was taken as the difference between the original (current) weight and the oven-dry weight expressed in per cent. of the oven-dry weight of an especially prepared section of the wood under test. These determinations in most cases were made by cutting and weighing sections in the field at the time of inspection and then baking them and making the final weight determinations in the chemical laboratory at Dehra Dun. In some cases, where the original weights could not be taken in the field, borings from the pieces to be tested were put into a tightly stoppered glass bottle and sent to Dehra Dun for weighing, baking, and reweighing.

#### (v) SYSTEM OF GRADING TIMBER AT FINAL INSPECTION.

It is by no means a simple problem to devise a satisfactory method of grading planks and scantlings so as to bring out accurately the difference in the results of seasoning by various methods. The system of grading timber commercially for ordinary defects is entirely inadequate, inasmuch as it does not take into consideration many of the defects that are of the greatest importance in comparing methods of seasoning. Obviously there are two general methods that may be followed; one is to determine the extent of the defects, the other is to determine the amount of sound material between the defects. At first thought it may appear that either method can be applied quite easily and that the results for the other can be quickly deduced. However such is not the case. Let us assume the case of a piece of timber which is split, surface cracked, and mouldy on the surface to a given extent, *i.e.*, to what we will call arbitrarily the second degree. From the standpoint of a comparison of seasoning methods it makes little difference whether these three defects overlap each other in one portion of the piece or whether they are entirely separate from one another and spread over the entire surface. From the standpoint of grading based on a certain percentage of sound material it makes

a great deal of difference as to how the defects are spaced, depending upon the size of the perfect piece to be sawn out—whether large pieces as for use in cabinet work or small pieces as for bobbins. The really ideal method to follow is to grade the different species according to the principal uses to which they are to be put, or at least according to standard sizes to be cut out. This was entirely out of the question under the conditions of these experiments. However for further investigations along this line, which will naturally lay more emphasis on commercial results, this method of grading should be developed and made use of.

The method followed in these experiments was to grade each piece according to the extent of each defect. The results, therefore, are of value only for comparison of methods and do not indicate the per cent. of damage or depreciation from a commercial point of view.

The extent or degree of each defect in every piece under test was indicated in the records by assigning it to one of four classes. If a given defect was present, but only to a degree of from 1 to 25 per cent. of its possible maximum development, it was recorded under Class I. If it was present to a degree of from 25 to 50 per cent. of its maximum development, it was recorded under Class II. Class III was used to indicate 50 to 75 per cent. maximum development and Class IV maximum development.

It is evident that such a system of determining the degree of the defect is based largely on the judgment of the inspecting officer. It would have been possible to devise a more accurate classification based on actual counts and measurements, but the time required to apply such methods over many large experiments would have been excessive and inconsistent with the general way in which the experiments were laid out.

The extent in each piece of timber of all defects except decay, insect attack, mould, and discolouration was indicated in the above manner. The reason for not attempting to indicate the degree of the latter defects lay in the fact that, inasmuch as they were partially invisible, the exact extent of damage could not be determined except by cutting the pieces into bits, planing the surface, etc., which was impossible under the circumstances. Therefore the mere presence of these defects was recorded against the piece.

In Divisions where the experiments were not inspected by officers from Dehra Dun no attempt was made to indicate the degree of defectiveness according to the above methods; in such cases the mere presence of a given defect was recorded.

#### (vi) METHOD OF SUMMARIZING DATA FOR COMPARISON.

The results of the detailed inspection have been reduced to the per cent. of the number of pieces under test in each case, the boards and scantlings being treated separately. However, the summary of

figures in Appendix I should be considered in terms of units of defectiveness rather than mere percentages, because of the fact that the original percentages have been weighted, or given values according to their relative importance, for the purpose of reduction to a common factor for comparison. For example, a certain percentage of pieces in an experiment were surface cracked to the first degree, a certain percentage to the second degree, etc., so that to arrive at the amount of surface cracking in the experiment as a whole it was necessary to establish a relation between the various degrees of defectiveness. This has been done by giving a Class II defect twice the weight of a Class I defect and weighting Class III and IV in the same direct proportion. Justification of this lies in the method of classifying the defect at the time of inspection.

In arriving at the sum of the defects under each method of seasoning unequal values have been assigned to the different defects according to the value of the defect as an indicator of the seasoning treatment—whether or not the defect is due to the method of seasoning only or to local conditions of piling and storage as well. Thus *surface cracking* has been taken at full value because more than any other defect it is a true indicator of the seasoning characteristics of the species and the method of seasoning. *Warping* and *twisting* have been taken at  $\frac{3}{4}$  value and *cupping* at  $\frac{1}{2}$  value, because, as the experiments were carried out, these defects were partly due to the method of piling. *Shake* has been considered at  $\frac{1}{2}$  value in that it is present in the wood before seasoning begins and is merely aggravated by the drying. *Splitting* has been taken at  $\frac{3}{4}$  value because it has started in the log before conversion, thereby making further splitting practically inevitable regardless of the seasoning method.

The conclusions drawn as to the seasoning characteristics of each species and the proper method of seasoning are based on the total of the units of defectiveness in each experiment and upon the percentage of pieces affected by decay, insect attack, mould, and discolouration. The general note written at the time of inspection giving the outstanding characteristics of the timber and a superficial comparison of the results has supplemented the detailed inspection.







Sheds of this type are entirely inadequate for refractory woods in the dry regions.  
The timber is insufficiently protected from the sun and wind.



These sheds are tightly closed on the side opposite the openings and are too wide with the result that there is insufficient circulation of air even for the most refractory woods in a dry region. The timber was badly moulded and decayed.

Method of Stacking and Sheltering the Timber for Air Seasoning Experiments,  
Gonda Division, U. P.

## CHAPTER III.

**Characteristics and Merits of the Four Methods of Air-Seasoning.**

The four methods of seasoning carried out in these experiments represent the generally recognised methods of air-seasoning timber commercially in this country. It is significant that these methods are in use more from necessity brought about by climatic conditions, or methods of timber extraction and manufacture, than from the actual beneficial effects of the methods themselves upon the timber. It is logical to assume from what may be seen from present practice that the seasoning is in most ways subordinate to other considerations, with the result that many woods are thought to be altogether incapable of seasoning satisfactorily.

The measure of the effectiveness of the seasoning method is not one of convenience or even of superficial cost, but rather of the extent to which the extremes of either too fast or too slow drying are avoided. If the seasoning goes on too quickly it becomes uneven and results in surface cracking and splitting. If, on the other hand, it is permitted to proceed too slowly every opportunity is given for the development of fungi and insects. The most effective method brings about the optimum conditions for the wood under treatment. Control of the rate of seasoning is absolutely essential in order to bring about the conditions which are most effective in preventing the characteristic seasoning defects of the wood.

The investigation shows that the susceptibility of certain species to damage by insects and decay is the primary factor in determining the proper method of seasoning; while in the matter of cracking, warping, etc., the care of the timber during seasoning is of the greatest significance. The protection that the converted timber is given from the sun, rain, and desiccating winds, and the care with which it is stacked, are of considerably more importance than whether it is seasoned in the log, by immersion in water, or by girdling the tree.

*(i) SEASONING IN THE LOG.*

Timber is seasoned in the log or square in order to reduce the amount of cracking by retarding the rate of drying. As a matter of fact, with many species seasoning in the log goes on so slowly as to be negligible for practical purposes, so that, even after a period of years, the heartwood is still quite green. As an example, it may be cited that sal logs laid down for seasoning showed after 4 years virtually no loss in moisture. The experiments show that with most species the seasoning is so slight, even after a period of one year, that when the logs are finally converted, the wood cracks and warps as much as though it had not been seasoned at all prior to conversion. Refractory woods, which specially require slow seasoning to

prevent excessive cracking and splitting and which are commonly thought to be benefited by this treatment, are often more damaged than by green conversion, inasmuch as the drying goes on quickly from the exposed surfaces, but not at all from the inside, with the inevitable cracking and splitting. By this method the portions of the log which season at all are usually so severely cracked that the material has to be sawn out and wasted when the logs are converted, so that the effects of the seasoning that does take place are almost entirely vitiated. As a rule, the cracks extend into the log to the depth that the seasoning has taken place or, in other words, the seasoning progresses only as far as the depth of the cracks and splits.

Excessive cracking and splitting may be reduced by leaving the bark on the logs and by painting the ends with a protective coating; but the seasoning is retarded to a degree that the time is practically wasted, and the timber is liable to damage from the effects of too slow drying, that is, by fungi and insects.

If decay is present in the tree in an incipient stage before felling, as it often is, it is given every opportunity to develop. But even if the logs are absolutely sound at the time of felling, the chances are very good that they will be attacked during the period of seasoning. The less durable woods such as *Tetrameles nudiflora*, *Sterculia villosa*, etc., are rendered absolutely useless by this method of seasoning, and the experiments have shown that in the majority of cases timber seasoned in this way is severely damaged. The practice of holding timber in the form of logs either for seasoning or for purposes of storage is responsible for much of the waste in conversion due to decay, splits, and cracks.

Some of the more valuable cabinet woods, such as *Dalbergia latifolia*, whose value depends largely upon the colour are said to be greatly improved by partial seasoning in the log before conversion. It is not to be denied that some woods may be held in the form of logs quite safely, and, if timbers whose colour is improved by this practice are included among them, the practice may well be continued.

The experiments carried out during the course of this investigation show that in general the surface cracking of the converted timber is no less by seasoning in the log than by green conversion. That is, taking the average of all species in all of the Divisions in which the experiments were carried out, the surface cracking was the same by seasoning in the log as by green conversion. On the same basis, splitting was 24 per cent. greater by seasoning in the log than by green conversion. As a general rule, and with most woods, the practice of seasoning in the log should be strongly discouraged inasmuch as there is much to lose and little to be gained through the practice.



## (ii) WATER SEASONING.

The theory underlying the practice of seasoning by immersion in water is that, while there can be no drying while the wood is under water, the constituents of the sap—the gums, tannins, and albuminous materials—are either subject to a slow chemical change or gradually leached out of the cells and are replaced by fresh water so that the subsequent drying may be carried out more quickly and with less loss due to cracking, splitting, etc. It is a fact that the original sap of the wood is much more difficult to extract during seasoning than ordinary water. For example, a piece of thoroughly seasoned wood, if soaked in water until it is entirely saturated, redries much more quickly and easily than when it was originally seasoned. But, when we consider the structure of wood and the anatomical obstructions to the ready flow of moisture through the cells, we come to appreciate fully how slowly the leaching process must proceed. Moisture in wood can penetrate but very slowly from cell to cell, usually by transfusion through membraneous structures, so that anything like a rapid replacement of sap by fresh water is impossible. The beneficial effects of soaking in water so far as cracking and splitting are concerned can be noticed, if at all, only after very long periods of time—periods, which under normal circumstances are entirely impracticable. It is said that Japanese craftsmen season some of their cabinet woods by immersing the pieces in freely moving water for several years. It is certain that soaking for a few months has no advantages, especially in the case of logs or large pieces.

The beneficial effects of the leaching process are more quickly realized in the case of converted material, but the increased difficulty of handling the timber under these circumstances makes the practice unfeasible under ordinary conditions. There are indications that planks and scantlings of the soft woods, such as *Bombax malabaricum*, which are especially liable to severe staining and discolouration upon exposure to the air, are benefited by immersion in running water. In this case it is not unlikely that the leaching effect is sufficient to cleanse the surface of the pieces and wash out the constituents of the sap near the surface so that the fungus germs do not get a firm foothold on the wood before the timber is dry. Analysis of the results of these experiments show that, taking the average of all species, surface cracking was 31 per cent. greater by water seasoning than by green conversion. Splitting was practically the same in both cases. It was noted further that the surface of pieces so immersed took on a dark, weather-stained appearance, and the grain was raised appreciably which, while doing no real damage to the wood, gave a suspicious appearance which in certain cases would affect the sale value.

Unless the water is clean, dirt and grit are embedded in the surface fibres so that machine knives and tools are quickly dulled when the wood is worked.

Immersion in water is of marked benefit in connection with the storage of logs and timbers either awaiting conversion or facilities for proper seasoning. As has been pointed out, the storage of wood in the form of logs or squares on land is decidedly hazardous. Therefore, where storage is necessary, immersion in fresh water is much to be preferred to ordinary storage on land. Cracking and splitting are prevented and organisms of decay will not develop. Likewise insect attack is prevented. It is absolutely essential, however, that the wood is *completely* immersed, otherwise severe cracking will occur above the water line, and insects and decay organisms are liable to damage the exposed portions. Another point of the greatest importance is that the water must be known to be free of teredos and other molluscs ordinarily found in salt and brackish water in rivers close to the sea and in adjacent backwaters. It is quite generally appreciated that these forms of lower animals are as destructive of wood as white ants and other insects.

The general conclusions to be drawn are that immersion in fresh water is effective as a means of eliminating the defects commonly attending the storage of logs and large timbers; but that from the standpoint of seasoning, benefits are to be realized only after periods of time which are entirely impracticable in ordinary practice.

### (iii) GIRDLING.

Girdling has come to be recognized as the standard method of seasoning teak and is claimed to have many advantages, in that it not only renders the logs light enough to float in water, but is said to reduce the subsequent cracking of the wood so that the wood may be used with little attention to further seasoning. It is common opinion that girdled teak is "thoroughly seasoned" and ready for use. It is an indisputable fact that girdled teak will float, and that ungirdled teak will not float, so that some appreciable degree of seasoning must take place after girdling and before felling. Some of the seasoning is accomplished through the evaporating surfaces of the crown of the tree, but this drying effect is limited entirely to the sapwood and, more particularly, to that portion just under the bark. Additional seasoning is accomplished through the periphery of the bole which soon becomes stripped of bark.

Although girdling accomplishes sufficient drying to permit of floating the logs, there is the question as to how much the main bulk of the log, i.e., the heartwood, is seasoned. There is abundant proof that even properly girdled teak cracks and shrinks badly when put to use in the dry regions, so that the theory that girdling in itself accomplishes thorough seasoning must be discounted. Comprehensive studies are under way in Burma to determine the effects of girdling various species, the degree of seasoning accomplished prior to conversion, etc. At the present time there is little information at hand to indicate the actual degree of seasoning that takes place in



the girdled tree. The only data available are based on tests made on girdled teak in the South Chanda Division in the Central Provinces. Since the trees under test had been girdled for a period of two years and three months, it may be assumed that the maximum effect, from a practical point of view, had been realized; particularly inasmuch as the climate of the South Chanda Division is nearly as dry as any forest region in India. The trees were entirely stripped of bark and were seasoned on the outside to the extent that the surface was cracked to a depth of 2 to 3 inches, and the trees were quite badly shattered and broken by the falling. Moisture content tests were taken 30 feet above the ground on three of the trees which averaged 15" in diameter at that point. The tests were taken at three points in the cross section of the logs; (1) in the sapwood about 2" from the periphery, (2) in the core of the tree, and (3) half way between the outside and the core. The moisture content of No. (1) averaged 20.3 per cent.; No. (2) 29.5 per cent.; and No. (3) 33.6 per cent. These figures prove quite conclusively that the main portion of the logs had seasoned but partially and was still quite green—fully capable of considerably more shrinkage. Thoroughly air-seasoned wood in the climate of that region has a moisture content as low as 7 per cent. In regions less dry than the Central Provinces the degree of seasoning accomplished by this method would be much less.

The experiments carried out under this investigation show that, with most species, girdling for 18 months reduced the tendency of the timber to surface crack after conversion and during final seasoning. The degree of reduction was more pronounced in some species than in others; but, taking the average of all species in all Divisions, the amount of cracking in the girdling experiment was about 24 per cent. less than by green conversion and seasoning in the log. The amount of splitting was somewhat less than by seasoning in the log and about the same as by green conversion and water seasoning. The reduction in cracking was probably due to the fact that the initial stages of seasoning were accomplished very slowly and uniformly in the standing tree, and that the wood had passed the most critical stage in the seasoning before being converted and stacked. This fact is of significance.

However, in a great many cases the girdled trees were badly attacked by borers in both the sapwood and the heartwood, greatly damaging the timber and, in certain cases, rendering it absolutely useless. It is obvious that some species are more susceptible to this kind of damage than others, and that certain species are more or less immune. There is so much uncertainty regarding the susceptibility of girdled trees to insect attack that girdling of most species involves considerable risk.

When the girdling of valuable species on a large scale is contemplated, the advice of the Forest Entomologist should be asked—as to the liability of the species to insect attack in the given locality, the

time of year that the girdling should be done in order to minimize the danger, etc., etc. Detailed data of this character are lacking at present, but should be made available through entomological investigations as occasion arises.

It must be borne in mind in connection with girdling that certain hard woods become more hard and difficult to saw after partial seasoning, as for example, *Terminalia tomentosa*, *Hardwickia binata*, and *Xylia dolabriformis*. Partial seasoning before felling also increases the liability of splitting and shattering when the tree is felled, particularly in species inclined toward shake and similar original defects.

Without going so far as to attempt to draw general conclusions, it may be pointed out that under the conditions of these experiments, as summarised in Appendix I, **the following species were not appreciably damaged by insects during girdling and generally benefited by the girdling treatment.**

Species.	Locality.
(1) <i>Aegle Marmelos</i> *	... United Provinces.
(2) <i>Anogeissus latifolia</i> *	... United Provinces and Central Provinces.
(3) <i>Anogeissus pendula</i> *	... United Provinces.
(4) <i>Bursera serrata</i>	... Ganjam, Madras.
(5) <i>Careya arborea</i> *	... United Provinces; Central Provinces; Ganjam, Madras.
(6) <i>Chloroxylon Swietenia</i> *	... Central Provinces.
(7) <i>Cleistanthus collinus</i>	... Central Provinces.
(8) <i>Eugenia Jambolana</i>	... United Provinces.
(9) <i>Grewia tiliaefolia</i>	... Central Provinces.
(10) <i>Melia Azedarach</i>	... Punjab.
(11) <i>Stereospermum chelonoides</i>	... Bengal.

Adding to this list the species which were found to season best by girdling and without damage from insects according to the previous experiments (vide *Indian Forest Records, Vol. VII, Part I*) we have:—

Species.	Locality.
(12) <i>Cedrela Toona</i>	... Bengal.
(13) <i>Dalbergia Sissoo</i>	... Punjab.
(14) <i>Dillenia pentagyna</i>	... Bengal.
(15) <i>Diospyros Melanoxylon</i> *	... Central Provinces.
(16) <i>Lagerströmia Flos-Reginæ</i>	Bengal.
(17) <i>Lagerströmia parviflora</i>	... Central Provinces.
(18) <i>Machilus odoratissima</i>	... Bengal.
(19) <i>Michelia Champaca</i>	... Bengal.
(20) <i>Morus indica</i>	... Punjab.
(21) <i>Schima Wallichii</i>	... Bengal.
(22) <i>Tectona grandis</i> *	... Central Provinces.
(23) <i>Terminalia Arjuna</i>	... Central Provinces.

The species which were obviously damaged by insects during the girdling under the conditions of these experiments, as summarised in Appendix I, are:—

Species.	Locality.
<i>Acer Campbellii</i> ...	... Bengal.
<i>Acrocarpus fraxinifolius</i> ...	... Bengal.
<i>Albizzia stipulata</i> ...	... Punjab.
<i>Alstonia scholaris</i> ...	... Wynaad, Madras.
<i>Boswellia serrata</i> ...	... Central Provinces and Bihar and Orissa.
<i>Calophyllum Wightianum</i> ...	... Coorg.
<i>Ficus asperima</i> ...	... Wynaad, Madras.
<i>Garuga pinnata</i> ...	... United Provinces and Ganjam, Madras.
<i>Hardwickia binata</i> ...	... Central Provinces.
<i>Hardwickia pinnata</i> ...	... South Mangalore, Madras.
<i>Holarrhena antidysenterica</i> ...	... United Provinces.
<i>Hopea parviflora</i> ...	... South Mangalore, Madras.
<i>Hopea Wightiana</i> ...	... South Mangalore, Madras.
<i>Odina Wodier</i> ...	... Central Provinces.
<i>Phyllanthus Emblica</i> ...	... United Provinces.
<i>Pterospermum acerifolium</i> ...	... Bengal.
<i>Soymdia febrifuga</i> ...	... Central Provinces; Bihar and Orissa; and Ganjam, Madras.
<i>Sterculia villosa</i> ...	... Bengal.
<i>Trewia nudiflora</i> ...	... United Provinces.
<i>Vateria indica</i> ...	... Coorg; and Wynaad, Madras.

Adding to this list the species which were found to be severely damaged by insects according to the previous experiments (vide *Indian Forest Records, Vol VII, Part I*) we have:—

Species.	Locality.
<i>Lagerströmia parviflora</i> ...	... Bengal.
<i>Ougeinia dalbergioides</i> ...	... Central Provinces.
<i>Stephegyne parvifolia</i> ...	... Central Provinces.
<i>Terminalia belerica</i> ...	... Bengal.
<i>Terminalia tomentosa</i> ...	... Central Provinces and United Provinces.

Species which were not seriously damaged by borers during girdling but for which the advantages of girdling are doubtful, unless necessary for extraction are as follows:—

Species.	Locality.
<i>Artocarpus hirsuta</i> ...	... Coorg.
<i>Calophyllum tomentosum</i> ...	... Coorg.
<i>Cassia Fistula</i> ...	... United Provinces.
<i>Dichopsis elliptica</i> ...	... Coorg.

Species.	Locality.
<i>Dipterocarpus turbinatus</i>	... Cōorg.
<i>Dysoxylum glandulosum</i>	... Coorg.
<i>Eugenia gardneri</i> ...	... South Mangalore, Madras.
<i>Frazinus floribunda</i> ...	... North-West Frontier Province.
<i>Gmelina arborea</i> ...	... United Provinces.
<i>Holoptelea integrifolia</i>	... United Provinces.
<i>Hymenodictyon excelsum</i>	... United Provinces.
<i>Juglans regia</i> ...	... North-West Frontier Province.
<i>Litsæa polyantha</i> ...	... Bengal.
<i>Saccopetalum tomentosum</i>	... United Provinces.
<i>Schrebera swietenoides</i>	... Central Provinces.
<i>Sterculia urens</i> ...	... Ganjam, Madras.
<i>Stereospermum suaveolens</i>	... United Provinces.
<i>Tetrameles nudiflora</i> ...	... Bengal.

Similarly, according to previous experiments, (vide *Indian Forest Records*, Vol. VII, Part I).

Species.	Locality.
<i>Adina cordifolia</i> ...	... Central Provinces.
<i>Albizzia procera</i> ...	... Bengal.
<i>Artocarpus Chaplasha</i>	... Bengal.
<i>Duabanga sonneratioides</i>	... Bengal.
<i>Pterocarpus Marsupium</i>	... Central Provinces.

**(a) Recommendations as to girdling when prompt conversion after felling is possible.**

So far as the facts can be judged from the meagre data available at the present time, and assuming that the logs can be converted soon after felling, the following general recommendations are made regarding the girdling of various species in the regions specified for a period of 18—24 months. The recommendations as regards girdling when the logs cannot be converted soon after felling are given in Chapter IX, page 76, *Treatment of Logs in Storage when Prompt Conversion is Impossible*.

- (1) When the timber can be placed in seasoning kilns immediately after conversion, girdling is unnecessary and involves too much risk unless it is essential to the scheme of extraction.
- (2) If the timber after conversion can be stacked immediately in specially constructed seasoning sheds and intelligently cared for during complete seasoning, only the species *starrei* on page 16 should be girdled.
- (3) If the timber immediately after conversion cannot be thoroughly seasoned under controlled conditions, but must be subjected to unknown and uncertain conditions of shipment, use, etc., girdling of species 1 to 23 on page 16 is recommended.



- (4) Concerning the other species experimented with to date, the evidence at hand indicates that girdling involves too much risk of damage from insects to make the practice feasible.

(iv) GREEN CONVERSION.

The conversion of logs immediately after felling, and the proper stacking and protection of the timber permit of greater control and regulation of the seasoning process than the other methods under consideration. Success with any of the methods depends, more than anything else, upon the care with which the timber is handled after conversion; and if this factor is given due consideration, most of the woods cut from green logs may be seasoned quite as satisfactorily as those cut from partially seasoned logs. Prompt conversion is the generally accepted practice in other large timber producing countries; and there is little to indicate that, in spite of the trying climatic conditions of India, it should not become the standard practice here.

Insects and fungi are the common enemies of timber, especially while in the log, and prompt conversion and controlled seasoning accomplish about all that can be done in preventing the development of these agents of destruction. By prompt conversion conditions which are the least favourable to the development of fungi and insects are brought about at once. The softer woods which are especially liable to this kind of damage must be converted green. Wood containing incipient decay, as many logs do to some extent, is exposed at once to the atmosphere by prompt conversion and thus loses quickly the moisture which is essential to the growth of decay organisms.

Under controlled conditions of seasoning even the most refractory woods may be seasoned quite as well by green conversion as by other methods. If logs are converted immediately after felling, the losses due to splitting are greatly reduced inasmuch as much of the splitting that occurs in converted timber is due to that which occurred, or at least started, in the log before conversion. Consequently, the sooner the logs are converted, the better will be the condition of the lumber. Boards and scantlings sawn from freshly cut logs do not show the tendency to split at the ends to the same extent as those cut from logs which have seasoned for some period of time. In these experiments the splitting by green conversion was on the average 24 per cent. less than by seasoning in the log. The experiments have shown further that surface cracking, on the average, is no more pronounced in timber converted green than in that held in the log for partial seasoning. This is particularly the case if proper care is taken to protect the freshly converted timber from too rapid drying as in the sun or by exposure to hot, dry winds.

That certain species *Odina Wodier*, for example, can be sawn only with the greatest difficulty in the green condition because of exudations of gum from the wood on to the saw cannot be overlooked. In



some cases this undoubtedly is something more than the fault of the saws, but the majority of woods saw more easily in the green condition than after they have become hardened through partial seasoning as, for instance, *Xylia dolabriformis* and *Terminalia tomentosa*. Certain species, such as *Dalbergia latifolia*, valued as cabinet woods are said to depreciate in value through a change in colour upon green conversion. These experiments did not take this factor into consideration although doubtless it is of importance in certain cases.

Although certain species taken up by this investigation have seasoned somewhat better by some other method than by green conversion, it is evident that the method is best adapted to the greatest number of species and should be followed as the standard practice. Under present conditions of handling timber in India prompt green conversion is not always possible, and it is often necessary to hold logs for long periods of time before conversion. However, it must be emphasized, that to do so has no advantage from the standpoint of seasoning and carries with it a considerable danger. In planning schemes for timber extraction and milling, this point must be given due consideration as a factor of primary importance.





Vertical piling under thatch cover. *Melia Azedarach* thus protected seasoned very well because the sheds were in a sheltered position. In general this type of shed is insufficient for refractory woods in the Punjab,



This shed was little better than no protection at all for refractory woods in a dry region. It is evident that the sun shines directly on the timber and the dry, hot winds have a free sweep.

Types of Sheds Used for Air Seasoning Experiments in Lahore Division, Punjab (above) and South Chanda Division, Central Provinces (below).

## CHAPTER IV.

## Seasoning Characteristics of the Various Species under Test.

It is impossible with our present knowledge accurately or finally to describe the defects that attend the seasoning of the various woods dealt with in this note. Under other conditions of climate, stacking, and sheltering, the timbers probably would have seasoned quite differently. The necessity of depending upon numerous officers to select the material, lay out the experiments, supervise conversion and stacking, and, in some cases, to make the final inspection has introduced variables leading to results which in many cases are not truly comparable, inasmuch as each individual officer had his own way of interpreting the general directions and putting them into effect.

The conditions surrounding the experiments as carried out were not exactly the same as might be expected in commercial practice, or in larger schemes, so that it is impossible to conclude as to how much degrade may be expected in actual practice. For example, as has been pointed out, the piles were very small in every case. The bulk of the timber itself offered little or no protection against excessive circulation of air. Moreover, the foundations were very uneven with the result that much of the timber was more badly cupped, warped, and twisted than otherwise would have been the case.

The most that can be done is to describe the general behaviour of the different woods during seasoning under the conditions surrounding the experiments in each Division, and the forms of depreciation to which they are especially liable. The experiments show with a varying degree of definiteness which of the four treatments gave the best results.

On the whole the results were good and indicate that most of the woods can be air-seasoned without excessive depreciation.

(1) **Acer Campbellii** (Appendix I—I). Darjeeling Division, Bengal.

The results from the seasoning of this wood indicate that it is a non-refractory species showing little tendency to crack, split, or twist. Decay and mould severely damaged the timber held in the logs for seasoning. Although the girdling experiment was not completed inasmuch as the trees died very slowly after deep girdling and were not absolutely dead until the end of two years, examination of the girdled trees showed that shot-hole borers had attacked the trees and apparently had done considerable damage. The living trees of this species are subject to attack by insects which leave large holes in the converted timber.



*Green conversion* gave the best results. There was no cracking, splitting, or discoloration in the pieces so seasoned.

*Seasoning in the log* resulted in a thick growth of black mycelium on the surface of all the pieces, which discoloured the wood and rendered it unfit for use. Also, the splitting was most pronounced under this method of treatment.

The liability of this species to insect attack in the log and to damage by mould and decay necessitates prompt conversion as soon as possible after felling, followed by open stacking under protection from rain and direct sun.

(2) **Acrocarpus fraxinifolius** (Appendix I—2). Kalimpong Division, Bengal.

The timber of this species seasoned easily and with few defects. There was practically no surface cracking, and but a slight amount of splitting, except in the widest boards. The sapwood of the unconverted logs appeared to be easily destroyed by decay and large borers, but the heartwood was quite immune.

*Green conversion* gave the best results in that the splitting was reduced to the minimum, and the sapwood as well as the heartwood was undamaged by fungi or borers.

*Seasoning in the log* and *girdling* gave the poorest general results, inasmuch as in both cases the sapwood was totally destroyed. *Water seasoning* and *seasoning in the log* increased the amount of splitting considerably.

For the best results this timber should be converted immediately after felling and carefully stacked under cover so as to accomplish prompt seasoning without exposure to the sun.

(3) **Aegle Marmelos** (Appendix I—3). Gonda Division, United Provinces.

This species is to be classed among the refractory woods which season with a marked tendency towards surface cracking, cupping, and twisting. Such tendencies were accentuated, in this case, because of the fact that most of the timber was cut from small logs. Damage by either white ants or borers was negligible. Sapwood longicorn beetles worked under the bark of the logs, but did not penetrate to a damaging extent. Unconverted timber was damaged by blue-stain both in the felled logs and in the girdled trees. There was no evidence of decay even in those pieces which were piled in a poorly ventilated godown.

*Girdling* reduced the surface cracking more than any other method, but the twisting and cupping, largely due to piling, caused sufficient damage to lower the general average below that of *seasoning in the log* and *water seasoning*. Moreover, the *girdling* resulted in more blue-staining than the other methods.



*Green conversion* resulted in more surface cracking and a lower general average than the other methods.

For structural purposes where blue-stain is no defect *girdling* and *seasoning in the log* gave the best general results. However, these methods must be avoided if the general appearance of the wood has to be considered; in which case, blue-stain would become an important defect.

The successful seasoning of this timber depends upon slow, uniform drying to prevent cracking, but with sufficient circulation of air to minimise the staining. The logs should be converted during or near the end of the rainy season.

(4) ***Albizzia stipulata*** (Appendix I—4). Kangra Division, Punjab.

This species showed a tendency toward rather severe splitting and was considerably damaged in the sapwood and outer heartwood by small borers, but otherwise seasoned very well. The living trees of this species are liable to attack by live-wood borers; consequently the seasoning has no effect upon this condition.

*Green conversion* gave the best results, largely due to the reduction in the splitting, and to the minimizing of the borer attack in the sapwood.

*Water seasoning* also reduced the splitting as compared with *seasoning in the log* and *girdling*, but the general results were lowered by the surface discoloration due to the immersion in water.

*Seasoning in the log* gave the poorest results due to splitting and damage by large and small borers. The sapwood was also decayed to a considerable extent.

This species seasons best when converted green, which treatment serves to eliminate the splitting and to reduce the damage done by insects and fungi. With proper methods of stacking and protection this wood may be seasoned with little depreciation.

(5) ***Alstonia scholaris*** (Appendix I—5). Wynaad Division, Madras.

The susceptibility to discoloration, decay, and insect attack were the principal characteristics attending the seasoning of this species. Other defects were negligible.

*Water seasoning* and *green conversion* gave the best results. There was the minimum of discoloration in the timber submerged in water for three months. Immersion in running water probably had the effect of washing off the sap from the exterior of the pieces and consequently reduced the amount of discoloration. However, the reduction may have been due partially to the season of the year at which the boards were stacked for final seasoning.

*Seasoning in the log* and *girdling* resulted in marked damage by borers, discoloration, and decay.

This species should be converted during the dry season, immediately after felling, and openly stacked in a free circulation of air so as to bring about immediate and rapid seasoning. If immersion of the converted timber in running water is feasible, the chances of severe depreciation from discoloration may be minimized by this treatment.

(6) *Anogeissus acuminata* (Appendix I—6). Porahat Division, Bihar and Orissa.

The species seasoned with considerable depreciation due to warping, splitting, and surface cracking. Although the warping was due partly to faulty sawing, the species otherwise showed a distinct tendency toward this defect. The splitting was most pronounced during seasoning in the log, but existed to a considerable extent in wood seasoned by the other methods as well. The species did not appear to be particularly susceptible to decay or insect attack, although borers did some damage in the timber converted green. It is probable that this damage was done to the logs between times of felling and conversion. The girdling experiment for this species was not completed at time of inspection.

*Green conversion* reduced the surface cracking and warping and gave the best general results.

*Seasoning in the log* resulted in the greatest amount of splitting and warping.

*Water seasoning* resulted in the most surface cracking, as well as in considerable splitting and warping.

The seasoning of this wood requires particular attention to the stacking to prevent warping, and upon conversion should be protected against rapid drying in order to minimize the surface cracking and splitting. The logs of this species should be converted during or near the end of the rainy season.

(7) *Anogeissus latifolia* (Appendix I—7). South Chanda Division, Central Provinces. Gonda Division, United Provinces.

The boards and scantlings of this wood showed a marked tendency to crack on the surface and, to a less extent, to split at the ends. In general the cracks were small, but numerous. Twisting, warping, and cupping accompanied the seasoning to a considerable degree.

Logs which were allowed to remain unconverted for 18 months were unattacked by insects in the Gonda Division, although there was some damage done by insects under similar circumstances in the South Chanda Division. Decay and discoloration were entirely absent.

Converted timber was unattacked by insects, decay, or discoloration during the seasoning, except that those pieces which were stored in a poorly ventilated shed developed a slight growth of

mould on the surface. Trees girdled in March and felled after 14 months were entirely unattacked by borers in the United Provinces, while those girdled in January and felled after 18 months in the Central Provinces were slightly attacked.

*Girdling* for 18 months followed by conversion and stacking gave better results than the other methods under trial, particularly with reference to surface cracking. *Seasoning in the log* gave results second to those of girdling. *Water seasoning* gave the poorest results. The twisting, cupping, and warping were more or less the same in all methods of seasoning.

Success in the prevention of the seasoning defects characteristic of this wood depends, more than anything else, upon the care of the timber after conversion as regards protection from too rapid drying. Ample shelter for the freshly converted timber is required. So far as possible, conversion should be carried out during or near the end of the rainy season.

(8) *Anogeissus pendula* (Appendix I—8). Gonda Division, United Provinces.

The species was represented in these tests by very scanty material. The timber seasoned with considerable surface cracking and cupping, but with little splitting. There was no evidence of insect attack of any kind. Decay and discoloration were also absent, although there was considerable mould on the surface of boards which were piled in a poorly ventilated shed.

*Girdling* gave the best results because of the reduction in surface cracking. This method, however, resulted in somewhat more twisting than the other methods, largely due to the method of stacking.

*Seasoning in the log* resulted in the greatest amount of surface cracking and gave general results considerably poorer than the other methods.

The important point to be borne in mind in seasoning this species is the necessity of adequately protecting the freshly converted wood against rapid drying so as to reduce the surface cracking. Careful stacking is also necessary to eliminate the cupping and twisting. Conversion should be carried out during the rainy season, or as near the end of the rains as possible.

(9) *Artocarpus hirsuta* (Appendix I—9). Coorg.

The results of the seasoning of this timber were very good and such as to justify classification of the species as a non-refractory wood. The amount of surface cracking was slight and did little damage to the timber. The cupping might easily have been prevented by greater care in stacking. There was no insect damage under any method of treatment. The sapwood of the timber seasoned in the log was somewhat decayed.

*Green conversion* gave the best results, inasmuch as the cracking and splitting were minimized.

*Girdling* gave somewhat the poorest general results due to a greater amount of surface cracking and splitting than in the other methods of treatment. However, the timber so seasoned was not as good originally as that dealt with under the other methods.

This species is obviously not exacting in its seasoning requirements, and may be expected to give very good results by almost any method, providing ordinary precautions are taken in the care of the logs and the converted timber.

- (10) **Boswellia serrata** (Appendix I—10). South Chanda Division, Central Provinces. Porahat Division, Bihar and Orissa.

The pieces representing this species seasoned very poorly, particularly in the South Chanda Division, in that the wood was severely damaged by decay, mould, and discoloration, as well as by white ants and borers. Other defects such as cracking and twisting were of minor importance in comparison, although severe splitting was a marked characteristic of the seasoning in the Porahat Division, probably due to delay in conversion.

The material *seasoned in the log* was absolutely useless because of decay and white ant attack, and severe splitting in the Porahat Division.

The *girdled* timber was somewhat less decayed but was damaged by small borers and was largely worthless.

Even *green conversion*, which might be expected to eliminate decay and mould, gave very unsatisfactory results. It will be noted, however, that the logs were not converted for two months after felling, which probably accounts for the depreciation.

All of the material in the South Chanda Division was converted during the rainy season. The results from the Porahat Division indicate that much of the mould and decay may be eliminated by green conversion during the dry season immediately after felling, followed by open stacking.

- (11) **Bursera serrata** (Appendix I—11). Ganjam Division, Madras.

The general results from the seasoning of *Bursera serrata* were fairly good, in spite of the pronounced surface cracking recorded at inspection. The cracks were numerous, but small and inconspicuous; and did little serious damage except in the case of the timber which was water seasoned. Splitting was not serious. The cupping which occurred was due entirely to the piling. The sapwood was somewhat damaged by fungi, white ants, and borers, but the heartwood was practically immune.



*Girdling* reduced the surface cracking and gave the best results except for the slight amount of insect damage. *Green conversion* gave fair results. *Seasoning in the log*, although resulting in the greatest amount of splitting, gave fairly good results aside from the damage by insects.

*Water seasoning* increased the surface cracking and gave the poorest general results.

*Green conversion* or *girdling* is recommended for this timber. In view of the liability toward surface cracking conversion during or near the end of the rainy season is desirable.

(12) ***Calophyllum tomentosum*** (Appendix I—12). Coorg.

The only significant seasoning defect recorded against this species was splitting. Although this timber is obviously inclined to split easily, the width of the boards into which the logs were cut accentuated this tendency. The surface cracking was negligible. There was little warping or twisting, and no damage from insects or fungi. The slight amount of cupping was due to the piling and could easily have been prevented.

There was no marked difference in the results obtained from the four methods of seasoning, although *green conversion* gave slightly the poorest general results and *seasoning in the log* slightly the best. Providing the ends of the converted timber and of the logs are protected against too rapid drying, it makes little difference what method of seasoning is used.

Although it is not clearly established by these experiments, it is generally true that the felling of trees which are partially dried out, as by *girdling*, has a tendency to increase the splitting and the shattering of the logs.

The splitting is accentuated by cutting the timber into wide pieces, especially if they include the core of the tree. This is a non-refractory wood and may be expected to season easily and well.

(13) ***Calophyllum Wightianum*** (Appendix I—13). Coorg.

This timber was considerably depreciated during the seasoning due to splitting, surface cracking, and cupping, and is to be classed as a wood of medium refractoriness. The timber is said to be generally of poor quality in Coorg. There was little decay or discoloration, and insects did no damage except to the girdled trees, in which case the sapwood and heartwood were rather badly riddled by large borers.

There was no marked or consistent difference in the results of the four methods of seasoning exclusive of *girdling*.

Although *water seasoning* gave the highest percentage of sound scantlings, the surface cracking and splitting, particularly of the boards, were increased by this method of treatment.



The *girdling* of this species is not recommended because of the liability to severe damage by borers both in sapwood and heartwood. From this it may be concluded that *seasoning in the log* is also hazardous due to insect attack.

- (14) *Careya arborea* (Appendix I—14). South Chanda Division, Central Provinces. Gonda Division, United Provinces. Ganjam Division, Madras.

This species is to be classed among the most refractory woods. It seasoned with as much damage from surface cracking, splitting, cupping, and twisting as any other species under test in these experiments. However, the material in each case was small and generally defective.

Although the few pieces of good material seasoned fairly well, the timber as a whole seasoned with considerable depreciation. Slight damage by borers was done to logs held for seasoning in the Gonda and Ganjam Divisions, and a certain amount of material under the water seasoning experiment was decayed due to storage in a badly ventilated shed. Discoloration in the logs or converted timber was entirely absent.

*Girdling* gave considerably the best general results both in the Gonda and South Chanda Divisions largely because of the reduction of surface cracking. In Ganjam there was little difference between *girdling* and *green conversion*.

*Seasoning in the log*, although involving a little damage by borers in the Gonda Division, reduced the surface cracking and gave results second to those of *girdling*. In the South Chanda and Ganjam Divisions *seasoning in the log* resulted in the most surface cracking and gave the poorest general results.

*Green conversion*, except in Ganjam Division, and *water seasoning* gave approximately the same results, both methods resulting in considerable surface cracking and cupping.

The most characteristic seasoning defects of this species are cracking, splitting, cupping, and twisting. The elimination of these defects depends primarily on the protection of the converted timber either from fresh or partially seasoned logs against too rapid drying and also upon careful stacking. This species should be converted during or near the end of the rainy season.

- (15) *Cassia Fistula* (Appendix I—15). Gonda Division, United Provinces.

This timber is to be classed as a refractory wood subject to severe damage by surface cracking, cupping, and splitting. There was a slight amount of damage done by borers in the sapwood of both logs and converted stock. The species is liable to borers in the living tree and to severe damage in the sapwood if the bark is left on. There was no evidence of decay even in those boards which were stored in a poorly ventilated shed.

*Girdling* reduced the surface cracking and splitting to the minimum and gave the best general results, although there was some slight damage by borers.

*Water seasoning* resulted in the greatest amount of surface cracking and cupping and gave by far the poorest general results.

*Green conversion* and *seasoning in the log* gave fairly good general results, although there was some borer attack in the sapwood in both cases. In spite of the fact that *girdling* gave the best general results *green conversion* is recommended for this species because of the liability to borer attack throughout the normally large sapwood if the logs are not promptly converted. Although this timber is inclined to crack and cup, if given proper protection and carefully piled, it can be seasoned with little depreciation. The logs should not be converted during the hot, dry season.

(16) **Chloroxylon Swietenia** (Appendix I—16). South Chanda Division, Central Provinces.

In both boards and scantlings this wood showed a decided tendency toward surface cracking and toward cupping and twisting to a lesser degree. There was no evidence of insect attack either in the logs, girdled trees, or converted timber. When converted green and exposed to the atmosphere, this wood darkened somewhat on the surface. This darkening effect was even more noticeable and penetrated to a greater depth in the pieces seasoned by immersion in water. *Seasoning in the log* and *girdling* prevented the change in colour altogether.

*Girdling* reduced the surface cracking more than any other method and gave the best general results. The material seasoned in this way was badly cupped and twisted, but this was largely due to the fact that the pieces were sawn from small logs.

*Seasoning in the log* gave general results second to those of *girdling* although there was considerably more surface cracking and splitting. For some purposes the darkening of the wood as it occurred in *green conversion* and *water seasoning* is not a defect, but for most of the uses to which this wood is put, discoloration must be avoided.

It is very essential to give this wood ample protection from too rapid drying immediately after conversion, and also to stack the pieces with care to avoid cupping and twisting. The logs should be converted during the rainy season.

(17) **Cleistanthus collinus** (Appendix I—17). South Chanda Division, Central Provinces.

Boards and scantlings seasoned with considerable surface cracking, cupping, and twisting. The species is to be classed with the most refractory woods. The material under test was cut from small

logs and, therefore, cracked and twisted badly. There was no discoloration or fungal growth except some decay which may have been in the tree before felling. There was a slight amount of insect damage in the girdled trees.

*Girdling* reduced the surface cracking more than any other method, but because of cupping and twisting gave general results slightly inferior to those obtained from *seasoning in the log*.

*Water seasoning* caused the greatest amount of surface cracking and gave the poorest general results.

This wood requires very careful handling during the seasoning to prevent excessive damage from cracking and twisting. After conversion the timber should be adequately protected against rapid drying. The twisting may be minimized by proper methods of stacking. The logs should be converted so far as possible during or near the end of the rainy season.

(18) *Dichopsis alliptica* (Appendix 1—18). Coorg.

Due to the brashness of the wood and to the fact that the unseasoned logs were full of shake and similar inherent defects, this species split very severely during the seasoning. There was little depreciation from warping and twisting, even in the wide boards, and the surface cracking was mostly along original defects in the pieces; consequently, in spite of the serious splitting, the wood can hardly be classed as especially refractory under the seasoning process. There was slight damage by borers in the felled logs held for seasoning.

The difference in the results obtained by the various seasoning treatments was not marked. However, there was considerable difference in the quality of the material tested under the four methods, and this must be taken into account in judging the results. The timber, especially the scantlings, converted from green logs had more original defects than that seasoned in the log prior to conversion. The boards subjected to water seasoning in the river broke away from their anchorage so that they were badly split.

*Seasoning in the log* is not recommended because of the liability to insect damage and splitting. Any of the other three methods may be followed although *green conversion* may be expected to give slightly better results than *water seasoning* and *girdling*. Inasmuch as *girdling* involves the felling of partially seasoned trees it probably increases the shakiness of the logs.

The seasoning process aggravates and brings out the inherent defects of this timber and therefore involves considerable depreciation due to splitting. However, boards and scantlings which are perfectly sound prior to seasoning should come through with little depreciation.

- (19) **Dichopsis polyantha** (Appendix I—19). Cox's Bazar Division, Bengal.

Since the report of the seasoning of this timber is incomplete, it is impossible to draw definite conclusions. The girdling experiment was not carried out. The data at hand indicate that this species is quite liable to considerable damage by surface cracking and splitting and, to a limited extent, to damage by borers.

*Seasoning in the log* appears to have minimized the surface cracking and splitting and to have given the best general results, although some damage by borers was incurred by this method. *Water seasoning* showed slightly poorer results than *green conversion*.

- (20) **Dipterocarpus turbinatus** (Appendix I—20). Coorg.

The results of the seasoning of this species were very good and justify classifying the timber among the moderately refractory species. Splitting was common in the wide boards but not excessive, and many of them seasoned with no twisting or cupping. Surface cracking was negligible in both the boards and scantlings. The amount of damage done by insects was very slight. White ants worked over the surface of a few pieces, and small borers were present in the sapwood of the timber supposedly converted green, but which actually lay in the log for five months before conversion. Some of the timber, especially that cut from girdled trees, was mouldy and discoloured, but this was due entirely to the manner in which the pieces were piled after conversion rather than to the girdling itself. There was some incipient decay in the sapwood of the timber seasoned in the log.

*Water seasoning* gave the poorest general results due to splitting and surface cracking.

*Green conversion* and *girdling* gave the best results, with little difference between them, after discounting the depreciation in the girdled timber from mould and stain which was actually due to faulty piling.

*Seasoning in the log* involved some damage from decay in the sapwood.

It appears that this species is not especially exacting in its requirements regarding the seasoning. Providing ordinarily good care is given to the logs and converted timber, very satisfactory results may be expected. Prompt conversion and facilities for fairly rapid seasoning are recommended for the species.

- (21) **Drimycarpus racemosus** (Appendix I—21). Cox's Bazar Division, Bengal.

The report as to the seasoning of this timber is incomplete; hence it is impossible to draw definite conclusions. The girdling experiment was not carried out. From data at hand, it appears that this



species is subject to considerable damage by surface cracking and splitting and was depreciated to a limited extent by borers.

*Seasoning in the log* minimized the surface cracking and gave the best general results in spite of some damage by borers.

*Water seasoning* appears to have given slightly poorer results than *green conversion*.

(22) **Dysoxylum glandulosum** (Appendix I—22). Coorg.

The wide boards, especially those including the core of the larger logs, split badly during seasoning, but the narrower boards and scantlings gave good results. However, this wood is liable to marked splitting along the original defects in the logs. The surface cracking occurred principally along the original defects in the timber and did not seriously affect the results. Warping, cupping, and twisting were negligible, so that in spite of the splitting this timber is to be classed among the less refractory species. There was no damage from insects or fungi except a marked blue-staining in the sapwood which occurred in all methods of seasoning, but was less pronounced in the case of *girdling*. This staining under *green conversion* and *water seasoning* was probably due to the fact that the logs were not converted immediately after felling.

*Girdling* gave somewhat the best general results, largely due to the reduction in splitting and blue-staining, although the results of the other methods of treatment were very good. There was little real difference in the results of the other methods. Prompt *green conversion* should be the most effective method of minimizing the staining of the sapwood, and inasmuch as the tendency toward surface cracking is not a marked characteristic of the timber, green conversion is recommended.

(23) **Eugenia gardneri** (Appendix I—23). South Mangalore Division, Madras.

The wood of this species seasoned very satisfactorily and with excellent results. Splitting was the most marked defect and was rather severe in the wide boards. The narrow boards and scantlings did not split badly. There was little tendency toward warping or twisting, and the cracking was negligible. Insects and fungi did no damage.

There was little marked difference in the results of the four seasoning treatments. *Green conversion* and *girdling* gave slightly the best general results, largely due to the minimizing of the surface cracking and splitting.

This timber is obviously not exacting in its seasoning requirements, and providing reasonable precautions are taken in the care of the logs and converted timber, very good results may be obtained.



- (24) **Eugenia Jambolana** (Appendix I—24). Gonda Division, United Provinces. Sambalpur Division, Bihar and Orissa.

This timber seasoned very well, with surface cracking as the most common defect. However the cracks were, on the whole, few in number and small. Splitting and twisting were present to a slight degree, principally in the boards seasoned in the log. In the Gonda Division there was no damage by insects or decay either in the logs or converted timber, but in the Sambalpur Division damage was done by insects in each method of seasoning. All of this may have been due to the delay in converting the logs. Boards piled in a poorly ventilated shed were undamaged by mould, whereas under the same conditions other species were badly decayed. This is an indication at least of the resistance of this species to fungus attack.

*Girdling* did more to reduce the surface cracking than other methods of seasoning and gave the best general results in the Gonda Division. In the Sambalpur Division *green conversion* gave the best general results. *Seasoning in the log* gave the poorest results largely due to splitting and cracking.

The problem involved in the seasoning of this species lies mainly in the prevention of surface cracking and splitting. Although *girdling* was the most effective method in this respect, equally good results may be obtained by *green conversion* if the converted stock is given protection from too rapid drying. This timber should not be converted during the hot, dry season.

- (25) **Eugenia operculata** (Appendix I—25). Cox's Bazar Division, Bengal.

An incomplete report as to the seasoning of this timber makes it impossible to draw definite conclusions. The *girdling* experiment was not carried out. The conclusion may be drawn that surface cracking and splitting are characteristic of this species and that the wood is subject to a limited extent to damage by borers.

*Seasoning in the log* appears to have minimized the surface cracking and to have given the best general results although some damage by borers was incurred by this method. *Water seasoning* gave slightly poorer results than *green conversion*.

- (26) **Ficus asperima** (Appendix I—26). Wynaad Division, Madras.

This species was severely damaged during seasoning by borers, decay, and discoloration. Live-wood borers caused considerable depreciation in all the timber, regardless of the method of seasoning, but during *seasoning in the log* and *girdling* small borers of a different variety did additional damage. Other defects, such as surface cracking and splitting, were negligible.

*Water seasoning* and *green conversion* gave the best general results. The discoloration in the former case was minimized, probably due to the washing off of the surface of the converted pieces.

thereby removing some of the constituents of the sap and rendering the wood less liable to the development of the discoloration.

*Girdling and seasoning in the log* resulted in excessive damage by borers, and by decay in the latter case.

Although this timber will be damaged by borers regardless of the method of seasoning, it should be converted, preferably in the dry season, immediately after felling and stacked in a free circulation of air for rapid seasoning. Immersion of the converted timber in running water for a short time will reduce the liability toward surface discoloration.

(27) **Fraxinus floribunda** (Appendix I—27). Hazara Division, N.-W. F. Province.

Except for the tendency to split, this wood seasoned with very satisfactory results. The warping noted was undoubtedly largely due to the stacking and could have been practically eliminated. Although there was slight evidence of borer attack in the timber seasoned in the log and in the girdled trees, no serious damage resulted.

*Girdling* resulted in the least splitting and gave the best general results, although the danger of damage by borers makes this treatment rather hazardous.

*Green conversion* gave results second to those of *girdling* and without any damage by borers. The splitting was partially due to splits and cracks in the logs from which the timber was sawn.

*Seasoning in the log* gave the worst results largely due to splitting and to the slight damage by borers.

The principal defect incident to the seasoning of this wood is splitting, which may best be avoided by either *green conversion* or *girdling*.

(28) **Garuga-pinnata** (Appendix I—28). Gonda Division, United Provinces. Ganjam Division, Madras.

The sapwood of this species seasoned with unsatisfactory results due to insect attack, sap stain, and decay. The heartwood remained sound and in good condition. The cracking, splitting, and twisting that occurred did not seriously damage the timber. The species is to be classed as of moderate refractoriness.

*Girdling and seasoning in the log* resulted in severe depreciation of the sapwood, but gave very good results as regards the heartwood.

*Green conversion* and *water seasoning* resulted in slightly more cracking in the heartwood, but served to reduce the depreciation in the sapwood. These methods are recommended for the seasoning of this timber.

The most essential point to be observed in the seasoning of *Garuga-pinnata* is prompt conversion of the logs immediately after felling in

order to save the sapwood from almost total destruction. The converted timber should then be carefully stacked and sheltered against rapid drying. It should not be difficult to secure fairly good results in the seasoning of this wood.

(29) **Gmelina arborea** (Appendix I—29). Gonda Division, United Provinces.

The boards and scantlings of this timber seasoned extremely well with practically no surface cracking, twisting, or splitting. Practically none of the boards were cracked at all and several of even the widest ones dried without any twisting or cupping. Many of the scantlings were perfect.

Discoloration and decay were entirely absent in the logs and in converted timber—even in boards which were stored in a poorly ventilated shed under very adverse conditions.

The susceptibility of this wood to damage by insects, borers, and white ants is the only factor of importance in deciding upon the most effective method of seasoning; and aside from this, there is very little difference in the results obtained by the various methods.

*Seasoning in the log* resulted in the least cracking and twisting, but a large proportion of the pieces were damaged by borers in the sapwood which brought the general average of results decidedly below that of other methods.

*Girdling* gave the best general results although this method is open to question because of the liability toward borer attack in the sapwood.

*Green conversion* gave excellent results, and in view of the fact that this method minimizes the insect danger, it is the method of seasoning recommended for the species.

(30) **Grewia tilioefolia** (Appendix I—30). South Chanda Division, Central Provinces. Gonda Division, United Provinces.

Although this wood seasoned fairly well, there was a marked tendency toward surface cracking, splitting, and cupping, particularly in the South Chanda Division. In the Gonda Division the timber seasoned without much depreciation from these causes. Insect attack in both Divisions was negligible both in the log and in the girdled trees. Boards piled in a poorly ventilated shed were slightly mouldy on the surface, but there was no decay in any case.

The amount of material under test in both Divisions was rather scanty and defective, making it difficult to draw accurate conclusions.

In the Gonda Division *seasoning in the log* resulted in the greatest amount of surface cracking and gave the poorest general results. The girdling experiment in this Division was not carried out. *Green conversion* and *water seasoning* gave practically the same results—much better than *seasoning in the log*.

In the South Chanda Division, where the timber seasoned with greater depreciation, *girdling* reduced the surface cracking and splitting very noticeably and gave by far the best results.

*Water seasoning* gave the poorest results due to cracking and splitting. This species obviously presents some difficulty in seasoning to avoid damage by cracking and splitting, but if the converted timber is given sufficient protection from too rapid drying and is carefully stacked, good results may be obtained. The logs should be converted during or near the end of the rainy season.

(31) *Hardwickia binata* (Appendix I—31). South Chanda Division, Central Provinces.

This timber seasoned much better than might be expected, considering its density, but must be classed among the more refractory species. The surface cracks, although numerous, were generally small. The cupping was serious, but much of it was due to the stacking and could have been reduced by more careful handling. There was little severe splitting or twisting, and no decay, or discoloration.

It is quite evident that this wood, if left in the log, is very susceptible to damage by borers in the heartwood and sapwood. Timber cut from girdled trees as well as that seasoned in the log was seriously damaged in this way prior to conversion.

*Girdling* reduced the surface cracking more than any other method and would have given very good results had it not been for the damage done by the borers. For this reason *girdling* and *seasoning in the log* must be avoided.

There was little difference between the results of *green conversion* and *water seasoning*. The amount of surface cracking and cupping was about the same in both cases.

Providing this timber is converted as soon as possible after felling to avoid insect attack, and the boards and scantlings are properly piled under sufficient protection against rapid drying, very good results may be obtained. The logs should not be converted during the dry season.

(32) *Hardwickia pinnata* (Appendix I—32). South Mangalore Division, Madras.

This timber was severely damaged during the seasoning throughout the sapwood by decay, discoloration, and insect attack. The heartwood seasoned easily with little cracking or splitting except along the original cracks and shakes in the centre of the logs. Clear pieces seasoned with no defects in the heartwood. Practically all of the cupping was due to the piling. This species is to be classed among the moderately refractory woods.



*Seasoning in the log* gave very poor results, particularly in the South Mangalore Division where the timber so seasoned was absolutely useless due to decay and deep discoloration.

Although *girdling* may appear to have given the best results, particularly in Coorg, the wood was severely damaged by borers, and the cracking and splitting were actually little less than by *green conversion*, so that *girdling* has no advantage over *green conversion* for this species.

The timber which was supposedly converted green actually seasoned in the log for five months before being converted so that the sap wood was severely discolored and decayed. Prompt conversion is the most effective way of reducing such defects and is recommended for this species.

(33) **Holarrhena antidysenterica** (Appendix I—33). Gonda Division, United Provinces.

This species can be classed among the less refractory woods—seasoning with little damage by cracking, splitting, or twisting, but liable to severe damage by insects. The pieces which were piled in a poorly ventilated shed were slightly discolored, but there was no actual decay.

*Seasoning in the log* gave somewhat the best results. Surface cracking, although not as little as by *girdling*, was less than by *green conversion* and *water seasoning*. The timber seasoned in the log was unattacked by insects although that from girdled trees was severely damaged by borers. Therefore it may be assumed that the immunity of the logs was accidental. In view of the susceptibility of this wood to severe damage by borers *seasoning in the log* and *girdling* are to be avoided.

*Girdling* reduced the cracking to the minimum, but resulted in almost total loss of timber due to the borers prior to conversion.

*Green conversion*, although resulting in the greatest amount of cracking, gave very good results, as a whole, and is the method of seasoning recommended for the species.

It is essential to convert the logs as soon as possible after felling and to stack the timber in a free circulation of air.

(34) **Holoptelea integrifolia** (Appendix I—34). Gonda Division, United Provinces.

This wood seasoned very well so far as surface cracking and splitting were concerned, but showed a marked tendency toward discoloration and decay. Surface cracking was negligible, and the cupping and twisting could have been prevented to a large extent by more careful stacking. Slight damage by borers occurred in the logs prior to conversion.



Although the timber converted green was badly degraded by mould on the surface, the depreciation was due plainly to conditions of storage.

*Water seasoning* actually gave the best results.

*Seasoning in the log* gave the poorest results, in that there was more surface cracking, but more particularly, because of the incipient decay in the sapwood and heartwood. The sapwood of this species is liable to severe damage by borers. *Girdling* also gave poor results probably because of the fact that the logs were not converted promptly after felling.

The essential point in connection with the seasoning of this wood is to convert the logs as quickly as possible after cutting, and to stack the timber in a well ventilated situation so as to accomplish thorough seasoning before decay and mould set in.

(25) *Hopea parviflora* (Appendix I—35). South Mangalore Division, Madras. Coorg.

Considering the density of the wood, this species seasoned with little depreciation and is to be classed among the moderately refractory species. Splitting and cracking were the principal defects. Splitting usually occurred along the core of the old trees in wide boards and, to a less extent, in pieces not containing the core. In the case of the former, the splits were widely developed, while in the latter, they were distinct but not excessive in size. The cracks, for the most part, were small and did not seriously damage the timber, especially for structural purposes. Many of the pieces, particularly the scantlings, were passed as perfect. Large borers did severe damage in the sapwood and outer heartwood in the girdled trees and to a less extent in the felled logs held for seasoning. The sapwood was somewhat discolored, but there was no evidence of actual decay.

*Girdling* reduced the splitting and the cracking and would have given the best general results had it not been for the damage done by borers in the sapwood and outer heartwood. Because of the liability to severe damage by borers, *girdling* is not recommended unless necessary for the scheme of extraction.

*Seasoning in the log* resulted in marked damage by borers in sapwood and outer heartwood, and also in considerably more splitting in pieces which did not contain the core of the tree.

There was little difference in the results of *green conversion* and *water seasoning*.

If this timber is converted green so as to avoid damage by borers and splitting, and the converted stock is piled under moderate protection from direct sun, very good results may be obtained.

(36) **Hopea Wightiana** (Appendix I—36). South Mangalore Division, Madras.

This species, which is said to be worthless as timber in this region, was depreciated very slightly during the seasoning by surface cracking, twisting, or splitting; but was severely damaged by fungi in both the heartwood and sapwood. Borers worked in the timber to a certain extent in the heartwood and sapwood, but in the former case the damage was probably done in the living trees by live-wood borers.

*Girdling* and *seasoning in the log* gave the poorest results because of decay. Curiously enough, in the former case the heartwood was badly decayed and the sapwood intact except for borers, while in the latter case the sapwood was decayed and the heartwood intact.

*Green conversion* gave the best results and is the treatment recommended for this timber. Prompt conversion immediately after felling is essential.

(37) **Hymenodictyon excelsum** (Appendix I—37). Gonda Division, United Provinces.

This timber seasoned very satisfactorily with little damage from cracking, on the one hand, or insects and decay on the other. Cupping and twisting resulted in some depreciation, but the damage from these causes might easily have been eliminated by more careful stacking. A few wide boards which were properly piled seasoned with no twisting whatever.

The wood which was *water seasoned* was somewhat attacked by white ants, but there is every reason to think that this damage was largely due to the storage conditions. *Girdling* resulted in slight blue staining.

*Girdling* and *green conversion* actually gave the best general results, and *seasoning in the log* slightly the worst; but all methods gave very satisfactory results with little real difference among them.

(38) **Juglans regia** (Appendix I—38). Hazara Division, N.-W. F. Province.

The principal defect noted in connection with the seasoning of this wood was splitting which was most pronounced in *seasoning in the log* and *water seasoning*. Surface cracking and warping were negligible. A slight amount of damage was done by borers in the living trees and to the timber during *seasoning in the log* and when *girdled*, but it was of little importance except as an indication of what may happen when this timber is not promptly converted.

*Seasoning in the log* resulted in the most splitting and gave the poorest results.

There was no marked difference in the results of the other methods of seasoning although *green conversion* reduced the splitting slightly more than the other methods and gave a little the best results.

If this wood is converted before the logs have been allowed to season and split, very good results may be obtained. Storage in the form of logs and *girdling* increases the risk of damage by borers.

(39) **Litsea polyantha** (Appendix I—39). Buxa Division, Bengal.

Insects and fungi rather seriously damaged this wood during seasoning. Cracking, splitting, and twisting were negligible in comparison. Borer attack was present in the timber under each method of seasoning. This was identified as that of "beehole borers" working in the living trees, so that the method of seasoning had little effect. Much of the timber was badly damaged by white ants. Decay and discoloration were present to a serious extent in cases where the logs were held for several months before conversion.

*Green conversion* gave considerably the best results. The colour of the timber was bright, and the damage by insects somewhat less than in the other methods. There was no decay in the timber so seasoned.

*Seasoning in the log* gave the poorest results because of decay and insect attack. The timber seasoned in this way was practically unuseable. *Water seasoning* increased the surface cracking and splitting.

None of the methods gave really satisfactory results, although, if the logs are converted immediately after felling, and if the timber is stacked openly and in such a manner as to reduce the liability to white ant attack, fairly good results should be obtained. Obviously no method of seasoning will eliminate the damage done by borers in the living trees.

(40) **Melia Azedarach** (Appendix I—40). Lahore Division, Punjab.

This species seasoned exceptionally well with no defects of particular significance. Some of the boards, particularly those sawn from logs which had been held for partial seasoning, were slightly split. There was a little surface cracking and warping but both were negligible from a practical standpoint. Neither decay nor insects had damaged the wood to the slightest degree. The timber under experiment was carefully protected from the sun and wind. This fact probably explains the good results obtained.

*Green conversion* resulted in more surface cracking and gave slightly the poorest results. Nevertheless the timber was in very good condition.

*Girdling* reduced the surface cracking and warping to the minimum and gave the best general results.

Apparently this timber may be seasoned successfully by any one of the four methods, providing the timber is carefully stacked and protected from sun and dry winds.

(41) **Odina Wodier** (Appendix I—41). South Chanda Division.  
Central Provinces.

The species is a moderately refractory wood, the heartwood of which is somewhat liable to damage by surface cracking, cupping, and twisting, and the sapwood very susceptible to severe depreciation by insects, mould, and decay. The heartwood is of such a nature that it seasons very slowly—more slowly than any other species under test. The heartwood of logs seasoned for 18 months and then converted into 1½" boards was still only partially dry nine months after conversion.

None of the methods were effective in preventing very severe depreciation of the sapwood by insects and decay. The heartwood seemed to be quite resistant to both insects and decay.

*Girdling* and *seasoning in the log* reduced the surface cracking and twisting of the heartwood, but resulted in incomplete seasoning and almost total destruction of the sapwood.

*Water seasoning* resulted in the greatest amount of surface cracking and twisting.

*Green conversion* immediately after felling is said to be very difficult because of an exudation of gum from the fresh wood upon the saw, but, it is thought, should give very good results as regards the seasoning.

None of the methods under trial gave satisfactory results. The seasoning of this wood is made difficult by the perishability of the sapwood and the extreme slowness of the heartwood in giving up its moisture.

It is probable that *green conversion* followed by careful stacking in a semi-open shed offers the best prospects of success in seasoning this wood.

(42) **Phyllanthus Emblica** (Appendix I—42). Gonda Division, United Provinces.

This species was found to be one of the most refractory woods under test due to a pronounced tendency toward surface cracking, cupping, and twisting. A certain amount of damage was done by borers, particularly in the logs prior to conversion. However, this species is known to be attacked by live-wood borers over which the method of seasoning brings about no measure of control. No decay nor discoloration was evident, although some of the boards which were stacked in a poorly ventilated shed were mouldy on the surface.

All of the pieces under test were sawn from small logs and were therefore more or less defective, making it difficult to judge as to the real effectiveness of the various methods of seasoning.

*Girdling* and *water seasoning* gave the best results, in that the surface cracking was considerably reduced by these methods. However, in view of the liability to severe damage by borers the former



method is not recommended. *Seasoning in the log* gave somewhat the poorest results as a whole, principally due to surface cracking and the attack of borers. *Water seasoning* or *green conversion* is recommended for this timber.

The point to be borne in mind in seasoning this wood is that ample protection from rapid seasoning immediately after conversion is absolutely necessary to prevent excessive surface cracking. The logs should be converted during or near the end of the rainy season. Proper stacking will do much to reduce the cupping and twisting.

(43) *Pterospermum acerifolium* (Appendix I—43). Kalimpong Division, Bengal.

Very satisfactory results were obtained in the seasoning of this wood. The chief characteristics of the seasoning were a slight tendency toward surface cracking and splitting and a rather marked liability to borer attack regardless of the method of seasoning. These borers may have got into the timber after conversion or during the short time that the logs were awaiting conversion. However, only in the case of the timber seasoned in the log did the borers do any serious damage. There was no decay in the heartwood in any case and but little in the sapwood. The freshly cut wood took on a reddish brown discoloration on the surface upon exposure to the air, but it was easily planed off. This was particularly noticeable in the case of *green conversion* and *girdling*.

*Green conversion* gave the best results because the surface cracking and splitting were reduced, and the damage done by borers was but slight.

*Seasoning in the log* resulted in serious damage by small borers in both heartwood and sapwood and also in considerable splitting.

*Water seasoning* increased the surface cracking.

The susceptibility of this timber to damage by borers while in the form of logs necessitates prompt conversion after felling. If the converted timber is piled under cover from direct sun to prevent surface cracking, very good results may be expected.

(44) *Saccopetalum tomentosum* (Appendix I—44). Gonda Division, United Provinces.

This species is to be classed as a moderately refractory wood subject to damage by surface cracking, cupping, and splitting if carelessly or improperly handled. A tendency toward discoloration in the sapwood, moulding, and attack by insects are marked characteristics of the timber.

*Green conversion*, although resulting in somewhat more surface cracking than *seasoning in the log*, gave the best general results aside from the mould which was due to piling the timber in a semi-tight shed.

*Water seasoning* gave good results—second to those of *green conversion*.



*Seasoning in the log* and *girdling* gave the poorest results—damage resulting from cupping and splitting and rather excessive surface cracking in the latter group. In addition, the timber seasoned by these methods was depreciated because of discoloration, especially in the former group.

Although this timber is liable both to cracking and to moulding and discoloration, it may be expected to give good results if the logs are promptly converted and the timber is properly stacked under some protection.

(45) *Schrebera swietenioides* (Appendix I—45). South Chanda Division, Central Provinces.

There was little surface cracking, twisting, or splitting in connection with the seasoning of this species, but a marked susceptibility to insect attack especially in *timber seasoned in the log*. In fact, damage was done by borers in all methods of seasoning except *girdling*. In the case of *green conversion* and *water seasoning* the damage was probably done before the logs were converted, inasmuch as they were allowed to stand for two months during the hot season after felling and before conversion. There was no evidence of decay or discoloration.

*Girdling* gave the best general results in that the surface cracking was minimized, and there was no insect damage. The absence of borers, however, was probably merely accidental.

*Seasoning in the log* also reduced the surface cracking and would have given good results except for the severe damage done by borers which rendered the timber so seasoned practically useless.

There was little difference between the results of *green conversion* and *water seasoning*. Both of these methods resulted in more surface cracking than *girdling* or *seasoning in the log*.

Providing this wood is given some partial protection immediately after conversion from too rapid drying, good results may be obtained. The susceptibility to borer attack makes *girdling* a decided risk and *seasoning in the log* practically futile. This timber must be converted as soon as possible after felling.

(46) *Soyrinda febrifuga* (Appendix I—46). Sambalpur Division, Bihar and Orissa. Ganjam Division, Madras. South Chanda Division, Central Provinces.

This timber is inclined to severe damage by surface cracking, splitting, and cupping, and also to depreciation by insects in the sapwood of unconverted logs and girdled trees.

In South Chanda *girdling* minimized the surface cracking and splitting and would have given excellent results except the timber was badly damaged by borers. In Ganjam and Sambalpur *girdling* gave no better results than the other methods; so that the advantages of *girdling* this species, especially in view of its liability to borer attack, are negative.

*Water seasoning* resulted in more surface cracking than the other methods and gave the poorest general results especially in South Chanda and Sambalpur.

*Seasoning in the log* was accompanied by considerable splitting, and in the South Chanda Division the timber so seasoned was badly damaged by borers. In Sambalpur and Ganjam the logs contained but very little sapwood and were unattacked by borers.

*Green conversion* gave the best general results. The cracking and splitting were not excessive, and the damage by insects was less than by other methods.

Wherever possible, prompt conversion during or near the end of the rainy season must follow the cutting of the trees. It is essential to provide ample protection against the sun and dry winds.

(47) *Sterculia urens* (Appendix I—47). Ganjam Division, Madras.

This species seasoned with few defects, except those due to white ants and fungi in the sapwood. The heartwood remained immune to insects and decay. Surface cracking, cupping, and splitting did little real damage to the timber. The wood is to be classed as a non-refractory timber.

Aside from the damage to the sapwood during *seasoning in the log*, all methods of seasoning gave good and much the same results. *Seasoning in the log* resulted in more surface cracking and splitting than the other methods and gave somewhat the poorest results. *Girdling* gave slightly the best results although not enough better than *green conversion* to warrant special effort.

In view of the susceptibility of this timber to severe depreciation in the sapwood, prompt conversion during the dry season soon after felling is recommended.

(48) *Sterculia villosa* (Appendix I—48). Kalimpong Division, Bengal.

The wood of this species is extremely liable to severe damage by decay and insects during the seasoning. Cracking and twisting were entirely absent, but there was some splitting in the timber seasoned in the log. On the surface of the converted pieces there was considerable discoloration, but it did not penetrate deeply into the wood. White ant attack was most noticeable in the vertically piled boards at the ends in contact with the soil.

*Seasoning in the log* and *girdling* resulted in unuseable material. In the former case the timber was badly decayed and eaten by white ants, and in the latter the borers had riddled the trees to such an extent as to preclude the use of the converted timber for any purpose.

*Green conversion* and *water seasoning* gave the best results.

Inasmuch as this wood is very liable to decay and insect attack, every effort should be made to convert the logs immediately after felling, preferably in the dry season. The pieces should then be openly

stacked under protection from rain so as to facilitate rapid seasoning under conditions non-conducive to white ant attack.

(49) **Stereospermum chelonoides** (Appendix I—49). Buxa Division, Bengal.

This timber showed a distinct tendency to surface crack, especially along the annual rings, in V-shaped cracks from the edges of the slash sawn boards, due to diagonal grain. This tendency was accentuated in numerous cases so as to resemble shake more than surface cracking. Insect attack and decay were negligible. The discoloration, which was present in each method of seasoning, was confined mostly to the surface of the timber and could be planed off easily. This timber seemed largely immune to white ant attack although it was piled in close proximity to *Litsæa polyantha* which was badly attacked.

*Girdling* and *green conversion* gave the best results in that surface cracking and shake were considerably reduced.

*Water seasoning* gave the poorest general results inasmuch as the surface cracking and shake were accentuated.

Unsatisfactory results were obtained from *seasoning in the log* although this method gave slightly better results than *water seasoning*.

The seasoning characteristics of this timber require careful attention to stacking and protection from the sun so as to avoid too rapid seasoning from the surface while the wood is green.

(50) **Stereospermum suaveolens** (Appendix I—50). Gonda Division, United Provinces.

This wood seasoned very well, whatever depreciation there was being due to a slight amount of surface cracking, cupping, and twisting. The cracks were small and caused little damage. The twisting was due to the fact that the material under test was sawn from small logs containing much sapwood. There was no evidence of decay even in those boards which were piled in a poorly ventilated shed. Insect attack was also absent except for a slight amount of damage by white ants.

*Girdling* gave the best general results because of the reduction in surface cracking. The twisting was most marked in this group due to the small logs from which the timber was cut.

*Green conversion* gave results second to those of *girdling* and but slightly worse.

*Water seasoning* resulted in the greatest amount of cracking and splitting and gave the poorest general results.

Although *girdling* and *green conversion* gave the best results it is evident that this species may be seasoned quite satisfactorily by any one of the four methods, of which *green conversion* is preferable.

(51) **Tetrameles nudiflora** (Appendix I—51). Kalimpong Division, Bengal.

This wood should be seasoned with little difficulty if carefully handled so as to avoid damage by insects. In these experiments

surface cracking was negligible. The wider boards, especially those converted green, which were so cut as to contain the core of the tree split badly, but the narrower boards seasoned without splitting. The cupping and twisting were due largely to the method of stacking and could have been prevented. Timber held in the log for seasoning was badly damaged by small borers and was also decayed. The storage of this timber in the log even for a short time is extremely hazardous.

*Green conversion* and *girdling* gave very good results with little difference between the two methods. However, in view of the liability to damage by borers *girdling* is not recommended.

*Water seasoning* resulted in considerable splitting and decay.

This timber may be easily seasoned and with good results if it is converted immediately after felling and stacked openly under protection from rain so as to accomplish rapid seasoning.

(52) **Trewia nudiflora** (Appendix I—52). Gonda Division, United Provinces.

The difficulty involved in the seasoning of this wood was due entirely to its susceptibility to decay, blue-staining, and insect attack. Other seasoning defects such as surface cracking, splitting, etc., were almost entirely absent.

*Seasoning in the log* and *girdling* gave very poor results because of the decay and staining, as well as the borer attack, that took place in the timber while in the logs.

*Water seasoning* gave poor results, as a whole, because of decay and insect attack, but most of this damage was due to the fact that the timber of this group was stacked in a poorly ventilated shed.

*Green conversion* gave the best results, but even in this case there was some surface discoloration. There was no decay nor insect attack except at the ends of the vertically piled boards in contact with soil.

Apparently there is but one way of seasoning this species by natural methods and that is by *green conversion* immediately after the logs are cut, followed by open stacking (preferably vertical) in a free circulation of air so that the drying can go on as quickly as possible. This timber should be felled and converted during the dry season so that the surface of the pieces may be quickly dried off. Probably the only method of obtaining really satisfactory results in wet localities would be to kiln season this wood.

(53) **Vateria indica** (Appendix I—53). Coorg. Wynaad Division, Madras.

This timber presented no difficulties in the seasoning except those due to staining, decay, and insect damage. The wide boards, especially those seasoned in the logs, split rather badly, but there was little surface cracking or warping, etc. The wood is to be classed among the non-refractory species. Large borers did considerable damage to the logs held for seasoning and in the girdled trees in Coorg. White ants.



attacked all of the timber very readily. The timber seasoned in the log was badly decayed and discolored; in fact, even the timber converted from green logs was discolored on the surface.

*Seasoning in the log* gave the poorest results due to insects and decay.

*Green conversion* gave by far the best results in Coorg but second to those from *girdling in Malabar*. The borers in the latter Division did not do sufficient damage in the girdled trees to depreciate the timber severely; but in view of the damage done by borers in Coorg, *girdling* must be considered a very risky and unnecessary method of seasoning the species.

This timber should be converted, preferably in the dry season, immediately after felling, and the planks and scantlings piled in a free-circulation of air to bring about rapid drying.



## CHAPTER V.

### **The Moisture Content of Seasoned Timber and the Time Required for Seasoning according to the Climatic Conditions of Different Divisions.\***

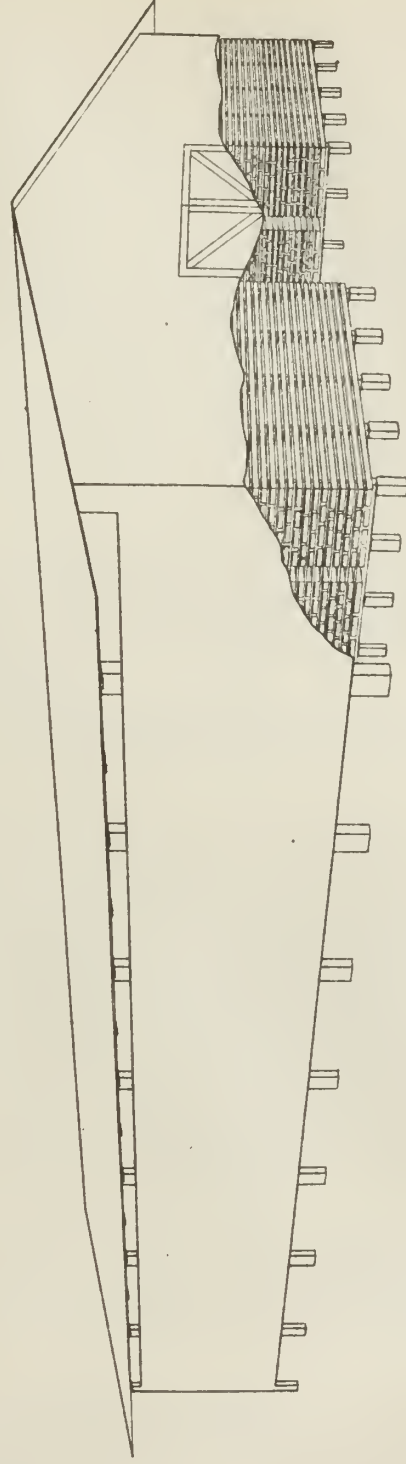
The investigation was not planned to give definite data as to the actual moisture content of timber which is in equilibrium with the climatic conditions of the various Divisions, nor to show the exact rate of seasoning of each species. These points are of such importance, however, in planning any seasoning scheme or in any attempts to ensure complete seasoning of timber before it is put to use, that an effort is made to set forth in this report the meagre data that are available and to go as far as possible in drawing conclusions that may be of practical use for guidance until more reliable and definite data can be accumulated.

Wood, like any other substance composed wholly or largely of cellulose, is hygroscopic and absorbs and gives off moisture according to the demands of the atmosphere that surrounds it. Tests made at the United States Forest Products Laboratory show that the hygroscopicity of all wood substance is quite uniform in that, when exposed indefinitely to a constant relative humidity at a given temperature, all wood substance regardless of the species will come to the same moisture content. From these tests curves have been drawn to show the moisture content of wood which is in absolute equilibrium with various atmospheric constants. Data of this kind based on laboratory tests are helpful as far as they go, but they do not supply an answer to the question as to the moisture content of seasoned timber in various climates, because the actual atmospheric conditions of any locality are not constant and uniform, particularly in most parts of India. The required data must be accumulated almost entirely from field investigation in the various localities.

In regions having an equable or oceanic climate the problem is greatly simplified. In regions characterized by marked seasonal fluctuations in the humidity of the atmosphere the soft, porous woods in small dimensions react very quickly to changes in atmospheric conditions so that they tend to go through the extreme range—from the maximum moisture content of the wet season to the minimum moisture content of the dry season. The more dense the wood and the larger the dimensions into which it is cut the slower the change in moisture content, so that it often happens that before a piece of timber has had sufficient time to come into equilibrium with one extreme,

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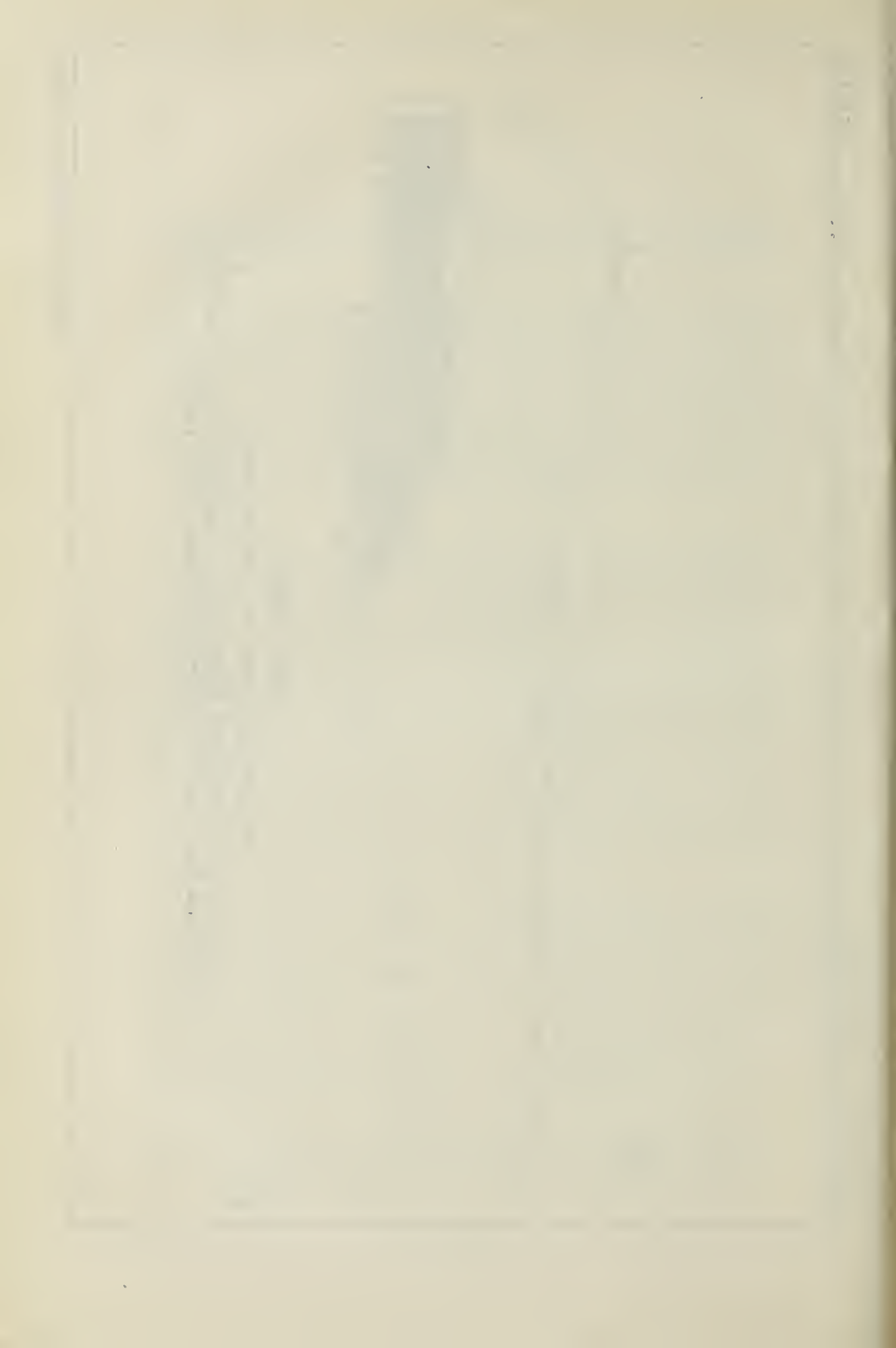
\* NOTE—It is hoped that in a short time sufficient data will be available to permit the revision of this Chapter so as to give more reliable and definite information regarding this very important phase of the subject of seasoning.



### CLASS I SHED

TYPE OF SEASONING SHED FOR REFRACTORY WOODS.

The type of construction may be that best suited to local conditions—thatch, wood, brick or bamboo and mud. See "Seasoning Sheds for Refractory Woods" page 63.



the atmospheric conditions have changed and the moisture content of the wood begins to go in the opposite direction.

The *rate* of change in moisture content varies with the species and the dimensions into which the wood is cut.

It may be pointed out here that the effectiveness of an adequate covering, such as paint or varnish, in preventing the swelling and shrinkage of wooden parts depends only upon the retarding of the *rate* of change, so that the part, under normal circumstances, does not come into complete equilibrium with either extreme of humidity.

From the above explanation it will be noted that the moisture content in any locality even of seasoned wood is subject to continual variation, and that the amount of the variation is dependent upon the climatic conditions, the species, and the dimensions into which the wood is cut.

The marked seasonal fluctuations in the atmospheric moisture conditions make it impossible with our present data to give an accurate figure to represent the moisture content of air-seasoned timber for any region of India. Even after further investigation and when the data are complete it may be necessary to give figures for different species and thicknesses.

With these factors in mind we may turn to the data available from the tests made in the different Divisions as summarised in Appendix I.

(i) GONDA DIVISION, UNITED PROVINCES.

The data available concerning the moisture content of seasoned wood in this Division are based upon 63 tests of 16 species, including both hard and soft woods. The determinations were made early in April, 1921 at which time the moisture content of the thoroughly air-seasoned pieces was probably somewhat below the mean of wet season and dry season conditions. Basing the calculations on the pieces of each species which there is every reason to believe were absolutely air-seasoned, *i.e.*, upon 1" boards converted from green logs and kept in open stacks for 25 months, the average moisture content was 8.3 per cent. The variation in individual tests was from 7.0 per cent.—9.6 per cent. which is a perfectly normal variation in thoroughly seasoned pieces even of the same species.

Using 8.3 ( $\pm 1.5$ ) per cent. as the moisture content in April of thoroughly air-seasoned boards 1" thick it will be noted in examining the figures for this Division in Appendix I, that each of the methods as summarized below has produced thoroughly seasoned wood at least in 1" boards.

- (1) 16—20 months in log after felling followed by conversion and stacking for 8 months.
- (2) Conversion immediately after felling, and stacking for 21—27 months.

- (3) Immersion in water for 4—6 months after green conversion followed by stacking for 21 months.
- (4) Girdling for 13—16 months, 2—5 months in log after felling. conversion followed by stacking for 8 months.

Although the maximum time required is established as above, there is no indication as to how much less time may suffice for equally thorough seasoning.

A mere opinion may be justified under the circumstances;—that any of the species experimented with in this Division may be thoroughly air-seasoned, after being sawn into 1" boards from freshly cut logs, in the period of 6—9 months of one dry season. The dense refractory species like *Careya arborea* and *Anogeissus latifolia* probably require the maximum nine months, beginning during the latter part of the rainy season and ending at the beginning of the rains. The softer woods such as *Gmelina arborea* and *Stereospermum suaveolens* can be air-seasoned in from 3—6 months after conversion, and timber of these species up to 2" in thickness can probably be thoroughly air-seasoned in one complete dry season. Timber in thicker dimensions will require proportionately more time.

Although data as to the approximate time required for air-seasoning is extremely necessary and useful, the actual degree of seasoning and final decision as to whether the timber is thoroughly air-seasoned should be based on the actual moisture content of the wood rather than on the length of time that it has seasoned.

About all that can be said at the present time is that timber 1" thick and thicker which tests 8·3 ( $\pm 1\cdot5$ ) per cent. or less between the end of the rainy season and the middle of the dry season may be considered thoroughly air-seasoned for this locality. Soft woods in the thinner dimensions,  $\frac{1}{2}$ " boards for example, which are to be regarded as thoroughly air-seasoned, may test as high as 16—18 per cent. during the rainy season, and 6—7 per cent. during the hot season. The more dense the wood and the thicker the timber the closer its moisture content should approach the 8·3 ( $\pm 1\cdot5$ ) per cent. at any time during the dry season.

#### (ii) SOUTH CHANDA DIVISION, CENTRAL PROVINCES.

The data available from the South Chanda Division are based on 105 tests of ten species, including woods of both high and low density. The determinations were made early in March when the mean humidity was about 4 per cent. above the normal. At this time the moisture content of the thoroughly air-seasoned pieces was probably at about the true mean of wet and dry season conditions. Basing the calculations on the pieces of each species which, there is every reason to believe, were thoroughly seasoned, i.e., upon 1" and  $1\frac{1}{4}$ " boards converted from green logs and stacked openly for an average period of 20 months, the average moisture content was 8·1 per cent. The variation in individual tests was from 7·2—10·2 per cent.



Using 8.1 ( $\pm 1.5$ ) per cent. as the moisture content in March of thoroughly air-seasoned boards 1" and  $1\frac{1}{4}$ " in thickness it will be noted in examining the figures for this Division in Appendix I to what extent the various species have seasoned according to each method. It is to be understood that the following figures are isolated determinations and do not establish the actual limits of thickness in which thorough air-seasoning has taken place. For example, under (1) it will be noted that *Chloroxylon Swietenia* is thoroughly air-seasoned up to a thickness of  $1\frac{1}{4}$ ". It is not known whether or not thicker material is also completely seasoned.

(1) 18 months in log after felling followed by conversion and stacking for 9 months.

**Completely air-seasoned up to thickness of  $1\frac{1}{4}$ ".**

*Chloroxylon Swietenia*.  
*Anogeissus latifolia*.  
*Grewia tiliæfolia*.  
*Schrebera swietenioides*.  
*Soyimida febrifuga*.  
*Cleistanthus collinus*.

**Not completely air-seasoned in thickness of  $1\frac{1}{4}$ ".**

*Hardwickia binata*.  
*Odina Wodier*.

(2) Conversion two months after felling and stacking for 20 months.

**Completely air-seasoned.**

*Chloroxylon Swietenia* in 1" boards and 4"  $\times$  4" scantlings.  
*Grewia tiliæfolia* in  $1\frac{1}{4}$ " boards.  
*Anogeissus latifolia* in  $1\frac{1}{4}$ " boards and 4"  $\times$  4" scantlings.  
*Schrebera swietenioides* in  $1\frac{1}{2}$ " boards.  
*Soyimida febrifuga* in  $1\frac{1}{2}$ " boards.  
*Cleistanthus collinus* in  $1\frac{1}{2}$ " boards.  
*Odina Wodier* in  $1\frac{1}{4}$ " boards and 4"  $\times$  4" scantlings (half sapwood).  
*Careya arborea* in  $1\frac{1}{2}$ " boards.

**Not completely air-seasoned.**

*Hardwickia binata* in  $1\frac{1}{4}$ " boards.  
*Cleistanthus collinus* in 4"  $\times$  4" scantlings.

(3) Immersion in water for three months after conversion within two months after felling, followed by stacking for 17 months.

**Completely air-seasoned.**

*Chloroxylon Swietenia* in  $1\frac{1}{2}$ " boards.  
*Grewia tiliæfolia* in  $1\frac{1}{2}$ " boards.  
*Anogeissus latifolia* in  $1\frac{1}{2}$ " boards.  
*Schrebera swietenioides* in  $1\frac{1}{2}$ " boards.  
*Soyimida febrifuga* in  $1\frac{1}{2}$ " boards.

**Not completely air-seasoned.**

*Hardwickia binata* in  $1\frac{1}{4}$ " boards.

**Completely air-seasoned.****Not completely air-seasoned.**

*Cleisthanthus collinus* in 1½" boards.

*Odina Wodier* in 1½" boards.

*Careya arborea* in 1¼" boards and 3" × 3" scantlings.

(4) Girdling for 18 months followed by conversion and stacking for 6—7 months.

**Completely air-seasoned.****Not completely air-seasoned.**

*Chloroxylon Swietenia* in 1¼" boards.

*Odina Wodier* in 1¼" boards.

*Grewia tiliæfolia* in 2" boards.

*Anogeissus latifolia* in 1½" boards and 4" × 4" scantlings.

*Schrebera swietenoides* in 1¼" boards.

*Soyimida febrifuga* in 1¼" boards.

*Hardwickia binata* in 1" boards.

*Cleistanthus collinus* in 1" boards.

*Careya arborea* in 1½" boards.

Inasmuch as the climatic conditions of the South Chanda Division are not unlike those of the Gonda Division and the moisture content of seasoned timber is practically the same in both Divisions, the opinions expressed on page 50 as to the time required for seasoning and the ultimate moisture content of air-seasoned timber are generally applicable to both Divisions. The heartwood of *Odina Wodier* and *Hardwickia binata* is very slow drying and the indications are that it will not air-season completely in 1" boards in less than 12—15 months after conversion.

**(iii) DARJEELING DIVISION, BENGAL.**

There was only one species under test in this Division. The moisture content determinations were made in February, 1921, when the humidity was normal for the month. Even though the calculations are based on 1" boards which had been converted and stacked for 24 months, there is considerable doubt as to whether the timber was thoroughly air-seasoned at 20·4 per cent. in view of the fact that most of it was crib-piled without crossers in a closed brick building. The atmospheric conditions in this godown must have been considerably different from the normal outdoor conditions of the region. The probable normal variation in moisture content of seasoned timber in this locality is from 24—26 per cent. in the rainy season to about 15 per cent. in April and May.

**(iv) BUXA DIVISION, BENGAL.**

The calculations as to the moisture content of air-seasoned wood in this Division are based on 51 determinations upon two species, made

in February, 1921, at which time the humidity was about normal. The moisture content of the thoroughly air-seasoned pieces was probably below the mean of wet and dry season conditions. As in previous cases, the moisture content of 1" boards which had been converted from green logs and stacked in open piles for a period of 24 months is taken as the standard of dryness for the region and season.

Taking 13.5 ( $\pm 1.5$ ) per cent. as the moisture content in February of thoroughly air-seasoned boards 1" thick, it will be noted in examining the figures for this Division in Appendix I that each of the methods as summarised below has produced thoroughly air-seasoned wood in the dimensions specified:

(1) 15 months in the log after felling followed by conversion and stacking for nine months.

*Litsaea polyantha* and *Stereospermum chelonoides* in boards up to 1½" in thickness at least, and 3" × 4" scantlings.

(2) Conversion one month after felling, and stacking for 24 months.

The above two species in boards up to 2" in thickness at least, and 4" × 4" scantlings.

(3) Immersion in water for four months after green conversion and followed by stacking for 20 months.

The above two species in boards up to 2" in thickness at least, and 4" × 4" scantlings.

(4) Girdling for 14 months, two months in log after felling, conversion followed by stacking for seven months.

The above two species in boards up to 1½" in thickness at least.

These deductions establish fairly definitely the maximum time required to air-season these species in the specified dimensions. As to how much less time would suffice only an opinion may be given at the present time. It is probable that both *Litsaea polyantha* and *Stereospermum chelonoides* can be thoroughly air-seasoned in pieces up to two inches in thickness, following conversion from green logs, in one complete dry season. Scantlings up to 4" × 4" of *Litsaea polyantha* can probably be air-seasoned in the same length of time, and 1" boards in from 3—5 months.

However, the actual moisture content of the converted timber should be the real criterion when determining whether any given lot of timber is sufficiently seasoned for use.

Timber 1" thick and thicker which tests 13.5 ( $\pm 1.5$ ) per cent. or less, between the end of the rainy season and the middle of the dry season may be considered thoroughly seasoned for this locality. Thoroughly air-seasoned thin boards, such as tea box shooks, may

even test as high as 24—26 per cent. immediately after the rainy season.

(v) KALIMPONG DIVISION, BENGAL.

The calculations as to the moisture content of air-seasoned wood in the Kalimpong Division are based on 60 determinations upon four species, made in February, 1921. The average moisture content of 1" boards which had been converted from green logs and stacked in open piles for a period of 25 months was 12.1 per cent. There is every reason to believe that the boards from which these tests were taken were completely air-seasoned to the atmospheric conditions of the locality.

Taking 12.1 ( $\pm 1.5$ ) per cent. as the moisture content in February of thoroughly air-seasoned boards 1" thick, it will be observed in examining the figures for this Division in Appendix I that each of the methods has produced thoroughly air-seasoned wood of all species in the dimensions specified, with one exception. Girdling for eighteen months and seasoning in the log for three months awaiting conversion, followed by open stacking for three months after conversion, was not sufficient to season 1" boards of *Acrocarpus fraxinifolius*, although similar treatment was sufficient in the case of *Pterospermum acerifolium*. However, this latter species, even though it was thoroughly air-seasoned to the conditions of an open thatch godown, developed small surface cracks when it was exposed to the sun after inspection. This fact is of significance as to the characteristics of the species and illustrates the point that thoroughly air-seasoned timber in this locality is not sufficiently seasoned to withstand exposure to direct sun.

It is probable that *Tetrameles nudiflora* and *Sterculia villosa* can be thoroughly air-seasoned up to a thickness of two inches following conversion from green logs in one complete dry season, and *Pterospermum acerifolium* and *Acrocarpus fraxinifolius* up to a thickness of 1½" in the same time.

Timber 1" thick and thicker which tests 12.1 ( $\pm 1.5$ ) per cent., or less, between the end of the rainy season and the middle of the dry season may be considered thoroughly air-seasoned for this locality. Thoroughly air-seasoned thin boards, such as tea box shooks, may test 24—26 per cent. immediately after the rainy season and from 8—10 per cent. at the end of the dry season. The difference in the rate of change in the moisture content of different thicknesses of boards is shown in the case of ½" and ¾" *Tetrameles nudiflora* and *Sterculia villosa* in which the moisture content was more completely in equilibrium with the atmospheric conditions at the time of inspection than was the case of the 1" *Pterospermum acerifolium* in which there was a pronounced "lag" due to the effect of the higher humidities prevailing during the two months preceding the inspection. Both the ½" *Tetrameles* and the 1" *Pterospermum* must be considered thoroughly air-seasoned for the locality; the difference in moisture content being



due entirely to the difference in the rate of response to the fluctuating atmospheric conditions of the region.

(vi) COX'S BAZAR DIVISION, BENGAL.

The moisture determinations of the seasoned timber in the Cox's Bazar Division were made in June, 1921, when the humidity was normal. The calculations were based on a total of 26 determinations upon three species. It is probable that in this Division the timber in June was in a state of maximum dryness. The seasonal variation in moisture content in this region is considerably less than in most parts of India, due to the uniformly high atmospheric moisture conditions throughout the year. Practically all the tests were taken on 4"  $\times$  3" and 4"  $\times$  4" scantlings, and there is no certainty that such thick pieces were thoroughly air-seasoned. However, the moisture content of the scantlings was so uniform in different tests and actually averaged the same as the 1" boards of *Dichopsis polyantha*, which had been openly stacked for 28 months, that there is considerable justification in concluding that both 1" boards and 4"  $\times$  4" scantlings were in equilibrium with the atmosphere at 15.2 ( $\pm$  1.5) per cent.

The records in Appendix I for this region indicate that seasoning in the log for 17 months followed by conversion and stacking for one year was sufficient to accomplish thorough air-seasoning of 4"  $\times$  3" and 4"  $\times$  4" scantlings of *Eugenia operculata* and *Dichopsis polyantha* but not *Drimycarpus racemosus*. Green conversion followed by open stacking for 28 months was sufficient for the thorough air-seasoning of 4"  $\times$  3" scantlings of each species.

The experiments in this Division do not justify any conclusions as to how much less time is required for thorough air-seasoning.

The moisture content of seasoned timber at the time of maximum normal atmospheric humidity is approximately 22 per cent.

(vii) SAMBALPUR DIVISION, BIHAR AND ORISSA.

The data available concerning the moisture content of seasoned timber in this Division are based on two species and 38 moisture determinations. The tests were made in March, 1921 at which time the moisture content of the thoroughly seasoned pieces was probably well below the mean of wet and dry season conditions. Basing the calculations on the pieces of each species which were known to be absolutely air-seasoned, i.e., upon 1" boards converted from logs which had been allowed to season for three months prior to conversion, and stacked in open piles for 25 months, the average moisture content was 7.0 per cent.

Using 7.0 ( $\pm$  1.5) per cent. as the moisture content in March of thoroughly air-seasoned boards 1" thick it will be observed from Appendix I that each of the methods as summarized below has



produced thoroughly air-seasoned wood at least in the dimensions specified.

- (1) 18 months in the log after felling, followed by conversion and stacking for 11 months.

*Eugenia Jambolana* and *Soymida febrifuga* in 1" boards.

- (2) Conversion three months after felling, followed by stacking for 25 months.

*Eugenia Jambolana* and *Soymida febrifuga* in 1" boards and the latter species in 2" boards at least.

- (3) Immersion in water for three months after conversion, followed by stacking for 22 months.

*Eugenia Jambolana* and *Soymida febrifuga* in 1" and 2" boards.

- (4) Girdling for 14—18 months, followed by conversion and stacking for six months.

Both of the above species in 1" boards.

*Soymida febrifuga* will probably require one complete dry season after conversion, beginning during the latter part of the rainy season and ending at the beginning of the rains, for thorough seasoning of 1" boards. *Eugenia Jambolana* can probably be air-seasoned in 1" boards in from 5—6 months and up to 1½" in thickness in one complete dry season. During a year of normal atmospheric conditions the moisture content of thoroughly seasoned wood in this Division may be as high as 19 per cent. at the end of the rainy season.

#### (viii) PORAHAT DIVISION, BIHAR AND ORISSA.

Data are available from two species under test in this Division. However, due to the inconsistent and unexplainable results of the test of *Boswellia serrata* it is necessary to disregard this species in these calculations, and to deal only with the 18 determinations on *Anogeissus acuminata*. The tests were taken in May, 1921 when the humidity was about 6 per cent. below normal. In the case of *Boswellia serrata* 1" boards which had been openly stacked for 27 months tested from 6·9 per cent. to 24·2 per cent. Such marked variation can be explained only by errors either in the determinations (which cannot be checked) or in taking readings from boards which had recently been rained upon.

The moisture content of 1" boards of *Anogeissus acuminata*, which had been converted from green logs and stacked for a period of 30 months, was 6·5 per cent.

Appendix I shows that each of the other methods of seasoning produced uniformly air-seasoned timber at least in 1" boards and in the case of green conversion up to 1½" in thickness.

It is thought that *Anogeissus acuminata* when converted into 1" boards can be thoroughly air-seasoned in one complete dry season.

Whenever possible it should be converted toward the end of the rainy season and stacked until the end of the hot weather. *Boswellia serrata* should be seasoned up to a thickness of 2" in one complete dry season.

The normal variation in the moisture content of seasoned timber in this Division is from about 11 per cent. in the dry season to 20 per cent. during the rains.

(ix) LAHORE DIVISION, PUNJAB.

The data at hand as to the moisture content of air-seasoned timber in the Lahore Division are based on 47 determinations of one species. The tests were made early in January, 1921 at the season of relatively high atmospheric humidity in this region. Basing the calculations on pieces which are certain to be absolutely air-seasoned, that is, upon 1" boards converted from green logs and stacked in open piles for 23 months, the average moisture content is 8.3 per cent.

There is evidence that 8.3 per cent. approaches the maximum moisture content even in the wet season of thoroughly air-seasoned timber in thicknesses of 1" and thicker in this region. The moisture content would be considerably less (probably as low as 4.5 per cent.) in the dry season particularly in  $\frac{1}{2}$ " boards which would come in complete equilibrium with dry weather conditions.

Using 8.3 (+ 1.5) per cent. as the moisture content in January of thoroughly air-seasoned boards 1" thick, it is evident from Appendix I that each of the methods, as summarized below, has produced thoroughly air-seasoned wood in the dimensions specified:

- (1) 18 months in the log after felling, followed by conversion and stacking for five months.

1" boards and 3" x 3" scantlings are thoroughly seasoned although  $3\frac{1}{4}$ " x  $3\frac{1}{4}$ " scantlings are not quite seasoned.

- (2) Green conversion followed by stacking for 23 months.

1" boards and 3" x  $3\frac{1}{2}$ " scantlings are thoroughly seasoned.

- (3) Immersion in water for four months after conversion, followed by stacking for 19 months.

1" boards and 3" x  $3\frac{1}{2}$ " scantlings are thoroughly seasoned.

- (4) Girdling for 18 months, followed by conversion and stacking for five months.

1" boards and 3" x 3" scantlings are thoroughly seasoned.

*Melia Azedarach* in 1" boards probably can be thoroughly air-seasoned in the six months of one dry season from January to June. Thicker dimensions will require proportionately more time.

(x) KANGRA DIVISION, PUNJAB.

The 22 moisture content determinations in Kangra were made on one species and were taken in July, 1921 after a very dry hot season.

The timber had probably passed the point of extreme dryness and had begun to show the effects of the higher atmospheric humidity conditions of the beginning of the rainy season. However, it was well below the mean of wet and dry season conditions.

The average moisture content of 1" boards, which had been converted from green logs and stacked in open piles for 30 months, was 8.9 per cent. The same timber probably would have tested 1 or 2 per cent. lower at the end of the dry season and somewhat higher at the end of the rainy season.

Taking 8.9 ( $\pm 1.5$ ) per cent. as the average moisture content in July of thoroughly air-seasoned boards 1" thick it is evident from Appendix I that each of the methods has produced thoroughly seasoned wood in 1" boards at least. There is a question as to whether the 30 months of seasoning after green conversion was sufficient for  $2\frac{1}{2}" \times 2\frac{1}{2}"$  scantlings. The data at hand is not sufficient to answer this question one way or the other. Limited knowledge of the seasoning of *Albizzia* indicates that it is a fairly slow drying timber. However, further investigation may show that 11.8 per cent. represents the air-seasoned condition for  $2\frac{1}{2}" \times 2\frac{1}{2}"$  scantlings in this region better than 8.9 per cent.

*Albizzia stipulata* in 1" boards, at least, can probably be thoroughly air-seasoned in the 6—8 months of one dry season.

(xi) HAZARA DIVISION, N. W. F. PROVINCE.

Two species were under test in the Hazara Division. The calculations as to the moisture content of air-seasoned timber in this Division are based on 28 tests on the two species. The determinations were made in June, 1921 and should truly represent the extreme of dryness to which seasoned timber in this region will come at the end of the dry season. The moisture content of 1" boards, which had been converted from green logs and stacked in open piles for 25 months, was 4.8 per cent. The average moisture content of  $6" \times 4"$  scantlings, which had been seasoned in the same way, was 5.6 per cent. There is every indication that each method of seasoning as shown in Appendix I for this Division was sufficient to accomplish complete seasoning for both 1" boards and  $6" \times 4"$  scantlings. The moisture content of thoroughly air-seasoned timber, particularly in the thinner dimensions, would be considerably higher (14—16 per cent.) after the wet season, but probably no lower than 4.8 per cent. at any season.

Both ash and walnut can probably be air-seasoned in 3—6 months between January and June in 1" boards, and in thicknesses up to  $1\frac{1}{2}"$ , at least, in 7—9 months between September and June.

(xii) COORG.

There were nine species under test in Coorg including woods of both high and low density such as *Hopea parviflora* and *Vateria*

*indica*. A total of 54 moisture determinations were made at the time of inspection in February, 1922. Taken at that season of the year they represent approximately the mean of dry seasonal conditions of the region. The average moisture content of 1" boards of all species, which had been converted from green logs and stacked for 18—24 months in open piles in a sheltered position, was 14·8 per cent. There is every reason to believe that the pieces from which the tests were taken were thoroughly air-seasoned for the region.

Using 14·8 ( $\pm 1\cdot5$ ) per cent. as the moisture content of thoroughly air-seasoned boards 1" thick in February, it may be concluded from data shown in Appendix I that each method of treatment has produced thoroughly seasoned wood at least in 1" boards with a possible exception in the case of *Hardwickia pinnata*.

There is little indication as to how much less time is required for equally thorough air-seasoning although it is evident that green conversion except in the case of *Hardwickia pinnata* and *Dipterocarpus turbinatus* has resulted in thorough seasoning of 2"  $\times$  4" scantlings as well as 1" boards in the periods specified.

It is probable that in this region of India fully nine months (including a complete dry season) are required for the thorough air-seasoning of 1" boards of the more dense woods such as *Hopea parviflora* and *Dipterocarpus turbinatus*. Evidently in the case of *Hardwickia pinnata* even more time is required. The less dense species such as *Vateria indica* and *Calophyllum tomentosum* probably can be thoroughly seasoned in 1" boards in one complete dry season.

Timber 1" thick and thicker which tests 14·8 ( $\pm 1\cdot5$ ) per cent., or less, between the end of the rainy season and the middle of the dry season may be considered thoroughly air-seasoned for the locality. Soft woods in the thinner dimensions, which may be considered thoroughly air-seasoned, will show a higher moisture content (from 24—26 per cent.) following the effects of the rainy season and a slightly lower moisture content at the end of the hot season. The more dense the wood and the thicker the timber the closer its moisture content should approach 14·8 ( $\pm 1\cdot5$ ) per cent. at any time during the dry season.

The above deductions are generally applicable to the Wynaad and South Mangalore Divisions, Madras. [See (xiv) South Mangalore Division, page 60].

(xiii) WYNAAD DIVISION, MADRAS.

Only three species were under test in this Division, and all of them were soft woods. Fifteen moisture determinations were made in February, 1922 at the time of final inspection of the experiments. The average moisture content of 1" boards sawn from green logs and stacked for 19 months in open piles in a sheltered position was 15·3 per cent.



Using 15.3 (+ 1.5) per cent. as the moisture content of thoroughly air-seasoned boards 1" thick in February, it is evident from Appendix I that each method has resulted in thoroughly air-seasoned timber in thicknesses up to at least 1" and *green conversion* up to 2½".

The climatic conditions of this Division are similar to those of Coorg, and the moisture content of air-seasoned timber is practically the same in both cases. The opinions as to the probable time required for air-seasoning in Coorg are directly applicable to the Wynaad Division.

(xiv) SOUTH MANGALORE DIVISION, MADRAS.

Four species of medium to high density were under test in this Division. The final inspection was carried out in February, 1922 at which time 18 moisture determinations were made. The average moisture content of 1" boards, which had been sawn from green logs and stacked in open piles for 30—32 months, was 14.9 per cent. The pieces from which these tests were taken were undoubtedly thoroughly air-seasoned for the region.

From the record for this Division in Appendix I it is reasonable to draw the following conclusions:—

- (1) *Hopca parviflora*:—Seasoning in the log for 27 months followed by conversion and stacking for six months, was insufficient to accomplish thoroughly air-seasoning for either 1½" boards or 4" × 4" scantlings.

Girdling for 17 months, followed by conversion and stacking for 15 months, was sufficient for thorough air-seasoning of 1½" boards at least.

- (2) *Hopca Wightiana*:—Seasoning in the log for 20 months, followed by conversion and stacking for 13 months, was sufficient for 1¼" boards at least.

Girdling for 16 months, followed by conversion and stacking for 14 months, was sufficient for the air-seasoning of at least 1½" boards.

- (3) *Hardwickia pinnata*:—Green conversion, followed by stacking for 32 months, was sufficient for the thorough air-seasoning of 4" × 4" scantlings.

Girdling for 18 months, followed by conversion and stacking for 13 months, was sufficient for at least 1¼" boards.

- (4) *Eugenia gardneri*:—Seasoning in the log for 27 months followed by conversion and stacking for six months, was insufficient for the thorough seasoning of either 4" × 4" scantlings or 1½" boards.

Girdling for 15 months, followed by conversion and stacking for 15 months, was insufficient to accomplish the thorough seasoning of 2" planks.



Inasmuch as the climatic conditions of this Division and the moisture content of air-seasoned wood are similar to those in Coorg and the Wynaad, conclusions which are drawn are applicable to the three Divisions. [See (xii) Coorg, page 58].

(xv) GANJAM DIVISION, MADRAS.

There were five species under test in Ganjam which, with one exception, were woods of high density. The final inspection was carried out in January, 1922 at which time 20 moisture determinations were made. Basing the calculations on the pieces which were certainly thoroughly air-seasoned, *i.e.*, upon 1" boards sawn from fresh logs and stacked for 28—33 months, the average moisture content was 11·5 per cent.

From the data in Appendix I we may conclude that the following methods of seasoning have produced thoroughly air-seasoned timber at least in boards 1" thick.

- (1) Seasoning in the log for 21—22 months, followed by conversion and stacking for 12 months.

*Soymida febrifuga*, *Careya arborea*, *Garuga pinnata* and *Sterculia urens*.

This method was not quite sufficient to accomplish the complete seasoning of *Bursera serrata*.

- (2) Conversion four months after felling followed by stacking for 28 months.

Each of the species under test in the Division was completely seasoned by this method.

- (3) Immersion in water for three months after conversion, followed by stacking for 30 months.

Each of the species under test as above.

- (4) Girdling for 14 months followed by conversion and stacking for 11 months.

Each of the species as above except, probably, *Soymida febrifuga*.

It is probable that any of the species dealt with in this Division can be thoroughly air-seasoned in 1" boards in about nine months providing the timber is converted and stacked during the rainy season so that it has a complete dry season after stacking. The softer woods in 1" boards, *i.e.*, *Sterculia urens* can be seasoned in from 3—6 months of the dry season.

Timber 1" thick and thicker which tests 11·5 ( $\pm 1\cdot5$ ) per cent. or less between the end of the rainy season and the middle of the dry season is to be considered thoroughly air-seasoned for this Division. Air-seasoned soft woods in thin dimensions may test somewhat higher prior to January following the effect of the rainy season and 2—3 per cent. lower during the hot season. The more dense the wood and the thicker the timber the closer its moisture content should approach 11·5 ( $\pm 1\cdot5$ ) per cent. at any time during the dry season.

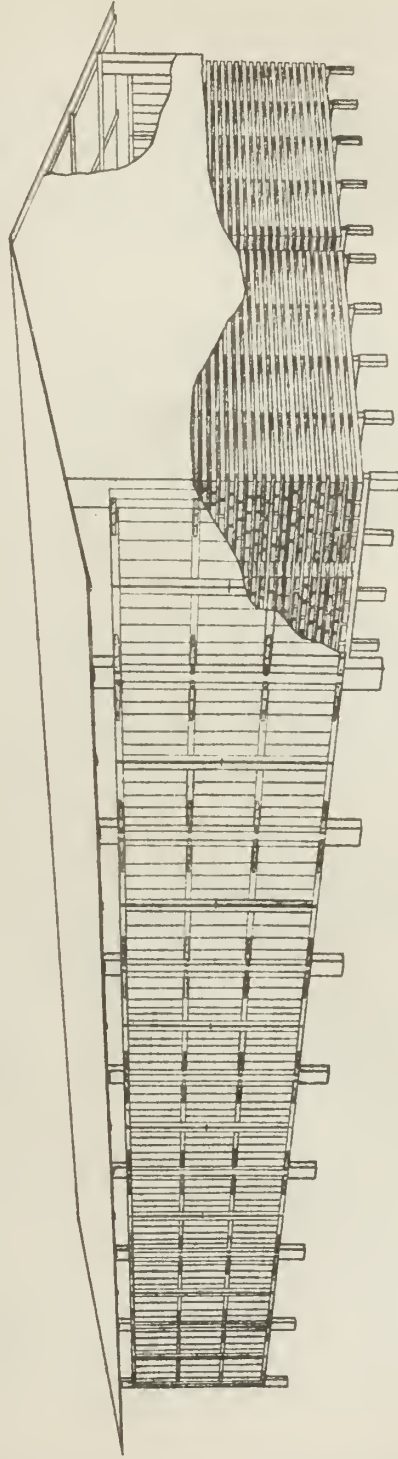
## CHAPTER VI.

## General Recommendations as to Methods of Stacking and Protecting Timber during Air-Seasoning.

The study of the various methods of seasoning timber in India has emphasized that, whatever method is followed, an item of the greatest importance is the attention that is given to the piling and sheltering of the lumber. Success with any method is largely dependent upon these two factors. The shelter provided to the green lumber affords the only control over the elements of nature possible in natural seasoning—by shutting out the direct effects of the elements and retaining around the timber, when required, a part of the moisture which is given off during the drying. It is the means of controlling the rate of drying within certain limits, and without some control success is a matter of chance. Most of the refractory woods will crack, split, and twist very badly if subjected to the fast drying conditions brought about by the hot sun and desiccating winds of many parts of India. It is impossible to expect the satisfactory seasoning of woods, such as *Anogeissus latifolia*, *Careya arborea*, etc., if the lumber is piled in the open and without protection from sun, rain, and winds. On the other hand, the same woods, but more particularly the soft woods, will discolour and decay if the seasoning goes on too slowly. There is an optimum rate of seasoning for each kind of wood and the seasoning method must aim at maintaining the optimum rate when it is once determined. The difficulties of maintaining the necessary control over the rate of drying in natural seasoning make it desirable to resort to artificial seasoning for exacting woods. In kiln seasoning it is possible to regulate and maintain the drying conditions to suit the requirements of the wood itself.

The amount and kind of shelter required for successful air-seasoning vary with the characteristics of the wood to be seasoned and with the climatic conditions of the region. Woods which have a tendency to crack and twist are the ones which suffer most from rapid seasoning and therefore require means of reducing the rate of drying by maintaining a relatively high humidity in the air surrounding them. This necessity is more marked in the hot dry regions than in the damp cool regions. However, there is danger of providing too much protection even in the drier regions with the result that the surface of the timber is perpetually moist, and the wood stains, moulds, and decays.

The woods of such species as *Trewia nudiflora*, *Bombax malabaricum*, etc., which have a tendency to discolour and decay, especially in regions of high atmospheric moisture, should be treated quite differently from refractory woods ; that is, the surface of the wood must be permitted to dry as quickly as possible, so that due to a lack of moisture the fungi germs will not have an opportunity to



### CLASS II SHED

TYPE OF SEASONING SHED FOR REFRACTORY WOODS.

The type of construction may be that best suited to local conditions—thatch, wood, brick or bamboo and mud. See "Seasoning Sheds for Refractory Woods" page 63.



develop. The protection in such a case should be from rain only. The sun and wind should be given full opportunity to accomplish the drying as quickly as possible. There is evidence that the most rapid drying possible in the moist regions is not sufficient to prevent some discoloration and decay in the softer species. In such cases artificial seasoning must be resorted to if the woods are to be used with any degree of satisfaction.

(i) SEASONING SHEDS FOR REFRACTORY WOODS.

The design and construction of seasoning sheds warrant careful consideration in order that they may meet the requirements of local conditions. The cost of a suitable shed is not an insignificant item, and it may seem formidable to operators who are inclined to pay little attention to the care of timber at this stage of manufacture. But if proper seasoning means anything in the value of timber, the question of the cost of sheds with reference to the results obtained may well be considered seriously.

It is obviously impossible to describe or furnish a specification for a seasoning shed that will best serve the purpose for all requirements. The design and construction must be in accordance with local conditions, *i.e.*, the climate, the species to be seasoned, the size and permanency of the project, etc. However, the essentials of a suitable seasoning shed to bring about the protection required for refractory woods, especially in a dry region, consist of the following items:—

- (1) a tight roof to keep off the sun and rain;
- (2) shelter at the sides exposed to sun and wind;
- (3) provision for ventilation under the roof and above the ground for admitting fresh air and getting rid of moisture evaporated from the wood;
- (4) strong, level foundations on which to pile the lumber;
- (5) drainage to prevent excessive soil moisture;
- (6) as much protection as possible against white ants and fungi.

(a) *Design and construction.*—The general type of shed best adapted to meet the above requirements is long and narrow with the length in the direction of the prevailing dry winds. The loading and unloading may be done from a central passage or drive-way through the shed from end to end, which for convenience may be designated as a Class I shed. In this type of shed the timber is piled for a distance of 16—18 feet on either side of the passage-way. Or the central passage-way may be omitted and the timber piled in from both sides—a Class II shed. In the former case the width of the shed should be about 40—50 feet, while in the latter 30—40 feet is sufficiently wide.

In a Class I shed the side walls are stationary and immovable and may be of any tight construction such as heavy thatch, mud, bamboo



and mud, wood, or brick—the essential point being that the walls protect the timber from wind and sun and do not extend way to the roof or to the ground. An opening  $1\frac{1}{2}$ — $2\frac{1}{2}$  feet wide should be left above and below the walls to permit sufficient circulation of air through the lumber piles.

In a Class II shed the side walls must be removable for loading and unloading. Walls consisting of a series of swinging or sliding doors (wood or thatch) provide a good permanent type of construction; but more temporary and cheap construction may be used effectively, as for example, by closing the sides, except the space under the roof and above the ground, with boards standing on end side by side on a support below and secured in a slot or collar above. This arrangement involves no great initial expense as the boards are available from those of less valuable species to be seasoned. Any or all of the boards may be easily removed for loading and unloading if no permanent fastenings are used; and, as the condition of the lumber requires, planks may be removed at intervals to allow a freer circulation of air through the shed.

Another type of shed, Class III, which may be used for woods of medium refractoriness or for refractory woods in a damp climate, combines the features of Class I and Class II sheds. Such a shed is virtually a half section of a Class I shed, *i.e.*, one side is permanently closed except under the roof and above the ground, and the other is open for loading and unloading with a sufficiently overhanging roof to protect the ends of the lumber piles from the elements. This type of shed should be open to the north, unless otherwise shaded, so that the exposed side will be in the shade. In extreme southern latitudes where the sun will shine on a north exposure during the hottest part of the dry weather, this type of shed should not be used unless it can be shaded artificially on the open side.

The roof in any type of shed may be of any construction which is weather proof, *i.e.*, thatch, tile, wood, or iron. The essential feature of the roof construction is that it should overhang the sides of the shed at least three feet so as to protect the space left for ventilation between the roof and side walls. Thatch construction involves a fire hazard that warrants serious consideration when used in the vicinity of sawmills. Uninsulated iron roofs exposed to the sun increase the temperature within the sheds and make the lumber more liable to crack.

The ends of the sheds should be tightly closed except for the doors in sheds having the central drive-way.

Within the seasoning sheds the lumber should be piled horizontally on suitable foundations and with proper crossers as detailed further on in this note. The piles should be raised from the ground sufficiently to permit a circulation of air under the piles.

(b) *Capacity*.—The capacity of a shed 100' long, 36' wide, and 14' high at the sides is from 200—275 tons of 1" boards. The division

or multiplication of such a unit for smaller or larger requirements obviously depends upon conditions which can not be considered here in detail. Under conditions where such a shed, even on a smaller scale, would be too large and permanent the necessary protection can be provided to the individual stacks of lumber by piling the timber on the proper foundations and then virtually building a shed over and around each pile. In such cases the roof may be of thatch or rough boards laid in such a fashion as to keep off the sun and pitched and overlapped so as to shed the rain. The ends and sides of the piles should be protected by tacking up rough boards or the equivalent of tight lattice work to keep off the sun and wind. The side protection may be removed gradually piece by piece as the condition of the lumber requires.

(c) *Requirements of various species.*—In large timber yards it is not necessary to provide seasoning sheds for all species, but the more refractory woods must be seasoned in sheds in any case.

Of the species dealt with in this investigation **the following are very refractory and liable to severe depreciation from surface cracking, splitting, and warping**, and must be given ample protection against too rapid drying.

*Aegle Marmelos.*  
*Anogeissus acuminata.*  
*Anogeissus latifolia.*  
*Anogeissus pendula.*  
*Careya arborea.*  
*Cassia Fistula.*  
*Chloroxylon Swietenia.*  
*Cleistanthus collinus.*  
*Dichopsis polyantha.*  
*Drimycarpus racemosus.*  
*Eugenia operculata.*  
*Grewia tiliacfolia.*  
*Hardwickia binata.*  
*Phyllanthus Emblica.*  
*Soymida febrifuga.*

Other woods of the same class experimented with previously (vide *Indian Forest Records, Volume VII, Part I*), are:—

*Bassia latifolia.*  
*Bassia longifolia.*  
*Diospyros Melanoxylon.*  
*Lagerströmia microcarpa.*  
*Lagerströmia parviflora.*

*Shorea robusta.*

*Terminalia Arjuna.*

*Terminalia paniculata.*

*Terminalia tomentosa.*

*Xylia dolabriformis.*

*Xylia xylocarpa.*

However, there are many kinds of timber that require only partial protection. The protection afforded by the surrounding piles in large yards is sufficient for woods which are not particularly liable to cracking, especially if the yard can be located with reference to a natural wind-break such as buildings, forests, or hills. In these cases, the layout of the yard should be such that the piles are arranged as compactly as possible in order to afford the maximum protection to each other. The drive-ways through the yards should be laid out perpendicular to the prevailing dry winds in order to minimize the air currents through the yard and so that the piles themselves, on either side of the drive, are placed with their length parallel to the direction of the prevailing dry wind. This means that the crossers which are put in between each layer of boards in the piles serve effectively as baffles to reduce the circulation of air through the stacks.

Individual piles in exposed portions of the yard require additional protection at the ends and sides. The ends of all piles exposed to the sun should be covered with a rough form of protection, such as boards or thatch, to prevent splitting.

In large yards where a roof over the whole is impracticable each pile must be covered to keep out the rain and direct sun either by thatch or by boards laid on a suitable pitch and overlapping to shed water.

Of the woods dealt with in this investigation **the following species are of medium refractoriness and moderately liable to crack and split**, but if given partial protection against rapid drying conditions, should season with very little depreciation. In large lumber yards the protection of the yard itself is sufficient, but when handled in small, isolated quantities these woods should be seasoned in sheds equivalent at least to a Class III shed as described previously.

*Bursera serrata.*

*Calophyllum Wightianum.*

*Dichopsis elliptica.*

*Dipterocarpus turbinatus.*

*Dysoxylum glandulosum.*

*Eugenia gardneri.*

*Eugenia Jambolana.*

*Garuga pinnata.*

*Hardwickia pinnata.*

*Hopea parviflora.*  
*Hopea Wightiana.*  
*Melia Azedaraeh.*  
*Odina Wodier.*  
*Saccopetalum tomentosum.*  
*Schrebera swietenoides.*  
*Stereospermum chelonoides.*

Other woods of the same class experimented with previously (vide *Indian Forest Records, Volume VII, Part I*), are:—

*Adina cordifolia.*  
*Cedrela Toona.*  
*Dalbergia Sissoo.*  
*Dillenia pentagyna.*  
*Duabanga sonneratioides.*  
*Lagerströmia Flos-Reginae.*  
*Morus indica.*  
*Ougeinia dalbergioides.*  
*Pterocarpus Marsupium.*  
*Schima Walliehii.*  
*Stephegyne parvifolia.*  
*Terminalia belerica.*

There are few if any lumber yards in India at present of such a size that some form of seasoning shed over the whole is unnecessary or impracticable.

#### (ii) THE TREATMENT OF NON-REFRACTORY WOODS.

The essentials of the seasoning practice for soft, non-refractory woods and those which are especially liable to damage by staining, decay, and mould, particularly in the moist regions, are almost the reverse of those described for refractory woods. The first essential is to accomplish rapid, rather than slow, drying by giving the timber adequate protection from the rains, but allowing a free circulation of air through the piles. Such conditions are ordinarily much easier to bring about than those for woods inclined toward surface cracking and splitting. The timber should be piled under the protection of a good roof with the piles so placed in relation to each other that all parts are exposed to the air currents. The adaptation of such a simple shed to small or large requirements is simple. For large lumber yards, where cover over the whole is impracticable, the individual piles must be covered. In such cases the drive-ways through the yard should be placed parallel to the direction of the prevailing winds so that the piles themselves will stand with their length perpendicular to the winds. The crossers between each layer will then



offer the least resistance to a free passage of air within and through the piles.

The following species are either particularly liable to staining, mould, and decay during seasoning, or else are capable of withstanding rapid seasoning, so that they should be stacked openly with no protection except from rain and direct sun.

*Acer Campbellii.*

*Acrocarpus fraxinifolius.*

*Albizzia stipulata.*

*Alstonia scholaris.*

*Artocarpus hirsuta.*

*Boswellia serrata.*

*Calophyllum tomentosum.*

*Ficus asperrima.*

*Fraxinus floribunda.*

*Gmelina arborea.*

*Holarrhena antidysenterica.*

*Holoptelea integrifolia.*

*Hymenodictyon excelsum.*

*Juglans regia.*

*Litsaea polyantha.*

*Ptereospermum acerifolium.*

*Sterculia urens.*

*Sterculia villosa.*

*Tetrameles nudiflora.*

*Trewia nudiflora.*

*Vateria indica.*

Other woods of the same class experimented with previously (vide *Indian Forest Records, Volume VII, Part I*), are:—

*Albizzia odoratissima.*

*Albizzia procera.*

*Anthocephalus Cadamba.*

*Artocarpus Chaplasha.*

*Bombax malabaricum.*

*Dalbergia latifolia.*

*Machilus odoratissima.*

*Michelia Champaca.*

*Pinus longifolia.*

*Stereospermum suaveolens.*

*Tectona grandis.*



For the softer species, such as *Bombax malabaricum*, *Trewia nudiflora* and *Sterculia villosa*, which are especially liable to stain and mould in the moist regions, the practice of end piling the boards on edge against a frame consisting of a horizontal centre pole supported from the ground at a sufficient height to support the pieces to be seasoned is recommended. If the pieces are piled in this way for a month or so after conversion, so that they are subjected to a free circulation of air, the surface of the wood is permitted to dry quickly and is therefore less liable to stain and decay. The boards should then be re-piled in horizontal piles under cover for complete seasoning.

### (iii) PILING PRACTICE.

The actual method of piling lumber or converted timbers during seasoning has much to do with the results obtained, inasmuch as poor, uneven piling results in crooked, twisted pieces. Wood while green is plastic and if piled on uneven foundations between crooked crossers will conform to the unevenness and when dry will retain the misshapes. If the methods of piling used by most of the forest officers in connection with these experiments are any indication of common practice in India, or of the general appreciation of the importance of these items, it must be concluded that the greatest stress should be laid on these details. The practice of piling lumber for seasoning on any convenient logs, whether sound or decayed, straight or crooked, or upon stumps or stones thrown down for foundations must be strongly condemned. Equal emphasis must be laid upon the use of stickers or crossers in laying up the piles to separate the layers of boards or scantlings. Specially prepared and selected strips are decidedly preferable to sticks of unequal length, thickness, and width which may be readily picked up. Scraps of wood picked up for the purpose are almost sure to be partially decayed and therefore a ready carrier of decay into the sound timber.

Crossers of improper dimensions cover too much of the surface of the wood to be seasoned with the result that an area of slow drying wood is established at the point of contact, in which fungi and insects find a favourable working place. It was brought out very clearly in these experiments that, where crossers had been selected carelessly without heed to their size and bearing on the timber, both decay and insect attack caused excessive depreciation in the timber in contact with the crossers. The use as crossers of narrow boards from those to be seasoned (crib piling) is to be condemned on the same score, *i.e.*, that there is too large an area of contact between the boards and crossers.

(a) *Foundations.*—The foundations upon which the piles are placed, either in the open yard or under sheds, must be such as to elevate the pile approximately 18" in order to give a free circulation of air under the pile and to lift the lumber above the dirt and accumulation of rubbish on the ground. They must be sufficiently firm and solid to prevent sagging of the pile and to provide an even bearing

surface for the pile to rest upon. Squared timbers are often used and are considerably better than rough logs, but unless they are especially treated with preservative, they are very short lived and soon rot away in contact with the soil—spreading fungal attack and insects to the sound timber. Concrete or brick work foundations are most satisfactory and permanent. They may be put in most economically as small piers spaced not more than four feet apart each way. Solid squared timbers such as 6" × 6" or 5" × 8" should be laid across the top of the piers perpendicular to the length of the pile in order to form a firm bearing for the timber.

(b) *Pitch of stacks.*—If the timber is to be seasoned in a shed, the foundations should be level or all of the same height. If the timber is to be yard piled, with but little protection from rain beating in at the sides, there must be a difference in the elevation of the foundations from front to back to give a pitch of 1 foot in 10.

The pitch of the pile may be either parallel or perpendicular to the length of the boards. The former method results in a more stable pile and a more compact yard and is the method commonly used. However, the latter method affords better and quicker drainage to any water that beats onto the timber, inasmuch as the crossers are in the same direction as the pitch instead of against it. Soft non-durable woods which must be exposed to frequent rains during seasoning should be piled according to the latter method.

(c) *Sorting of lengths and spacing.*—So far as possible, only pieces of equal length should be piled together in the same stack. When pieces of unequal length must be piled together, the longer pieces should be sorted out and placed at the bottom of the pile. Long pieces should never be allowed to overhang shorter ones. The location of the foundations should be such that the ends of the pieces to be seasoned rest on or immediately above the foundations.

In piling, a space of at least  $\frac{3}{4}$ " should be left between adjacent pieces. Where the width of the pile exceeds five feet an open space 8"—10" wide should be left in the centre of the pile from bottom to top. This chimney-effect permits of greater circulation in the inside of the pile. In excessively wide or continuous piles these central flues should be provided at least every four or five feet.

(d) *Crossers.*—The crossers used for separating the layers of boards should be specially selected, sawn from sound timber, and well seasoned. They should be of uniform thickness, approximately 1" in cross section for  $1\frac{1}{2}$ " boards and thinner material, and  $1\frac{1}{2}$ " for 2" boards and thicker timbers. They should be sufficiently long to extend across the entire width of the ordinary pile, but not to exceed six feet in any case.

The crossers should be placed at intervals not more than four feet along the length of the pieces. For woods which are particularly liable to twist and warp, the crossers should be placed at intervals not to exceed two feet. They should be placed one directly above

another in good vertical alignment. The vertical lines of crossers should bear directly upon the foundations, and those at the ends of the pile should be placed as nearly flush with the ends of the boards as possible.

(e) *Horizontal versus vertical piling.*—The method of piling, discussed above, deals principally with flat or horizontal piling. Both horizontal and vertical piling were tried in these experiments and the former seemed to give the better general results. It was impossible to detect any consistent difference in the amount of twisting, cracking, and staining. In cases where improper crossers were used the horizontally piled pieces were damaged by decay and insects at the point of contact, but there is no reason to think that this might not have been eliminated by more proper piling. On the other hand, most of the vertically piled boards were decayed and attacked by white ants at the ends in contact with the soil, in spite of the boards that were laid down on the ground for the ends to rest upon. In practically all cases this damage extended 6"—9" up the length of the piece and in many cases much farther. This form of damage is difficult to avoid.

Vertical piling ordinarily permits more free circulation of air around the pieces. This results in too rapid seasoning for the woods inclined towards surface cracking, but is quite beneficial for the softer woods which require rapid surface drying to prevent staining. Vertical piling ordinarily requires more space for a given quantity of lumber, and thus the question of covering it by a roof is made more complicated, at least for large projects. The usefulness of this method of piling is largely limited to short, preliminary drying treatments for woods inclined toward staining prior to horizontal stacking under cover for complete seasoning.

## CHAPTER VII.

### Sanitation of Lumber Yards and Timber Depôts.

Fungi and insects are two formidable enemies of wood during air-seasoning and storage. A certain amount of damage is unavoidable in that the timbers contain original infection before arriving in the yard, and little except prompt conversion and thorough seasoning can be done to arrest its development. But a large portion of the damage can be eliminated by maintaining more sanitary conditions in the yards. It is not a newly discovered fact that logs should not be allowed to lie in contact with the ground, and yet it is a very common sight in timber yards to see the logs partially embedded in the soil and overgrown with weeds and grass, apparently in utter disregard of the rapid depreciation that is taking place. In the course of a few inspections the writer has seen badly decayed logs, planks, and scantlings, which have been rejected because of their state of decomposition, growing luxurious fruiting bodies of fungi in close proximity to the other timbers in the yard. Decayed logs and sleepers used for foundations are often in direct contact with sound timber and naturally quickly spread infection. In fact, the ordinary timber yard, with its accumulation of decayed, defective pieces covering the ground, is an ideal harbour for both fungi and insects. Such an accumulation of rubbish adds greatly to the fire risk also.

The accumulation of chips, bark, and broken pieces to be found covering the ground in almost every timber yard should be gathered and burned. Pieces of timber rejected from the piles because of decay, insects, etc., should be removed from the yard and burned. Mere separation for a short distance from the main supply is not sufficient because the spores of the fungi and the insects easily find their way under the proper climatic conditions to the fresh timber.



## CHAPTER VIII.

## Season of Year for Girdling, Felling, and Conversion.

There is a common belief among practical timbermen that success in seasoning depends to a large extent upon the time of year that the trees are cut. Many theories are advanced—a difference in the chemical constituents of the wood and sap, a difference in the amount of moisture in the wood at various seasons, not to mention such impossibilities as the phase of the moon, etc. As to the different chemical changes in the wood and sap at various times of year in their effect upon the seasoning process, but little is known. At the present time they must be discounted as being of minor importance.

It has been established quite conclusively that the actual amount of water in a living tree (at least in the temperate zones) varies but slightly with the season, the moisture content during the dormant season being about the same as during the growing season. The slight differences that do occur are limited entirely to the sapwood and from the standpoint of seasoning are negligible. The conclusion to be drawn is that it is the conditions to which the timber is subjected immediately after cutting that are of importance rather than the condition of the wood itself prior to cutting.

## (i) GIRDLING AND FELLING.

If logs can be converted into boards and scantlings within a short time after they are felled and the lumber placed at once into a seasoning kiln, or if the logs can be submerged in fresh water soon after felling, the time of cutting is of no importance as regards the seasoning.

In the case of logs which for any reason must be held unconverted for a period of months (unless under water) the season of felling and girdling is a very important factor. If trees are felled and cut into logs immediately before or during the hot weather, the refractory woods particularly will crack and split excessively. During the hot weather and at the beginning of the rainy season wood-destroying insects and fungi are very active and are apt to do excessive damage to freshly cut logs, particularly of the less resistant species. In general, logs which cannot be converted or submerged in fresh water very soon after felling should be cut between the end of the rainy season and the middle of the cold weather.

Species differ widely in their susceptibility to the factors that lead to depreciation of timber in the form of logs. The time of cutting that reduces the depreciation to the minimum must be worked out experimentally for every kind of timber and region. Experiments with this point in view are being undertaken in Burma for several important species.



The effect of the time of year of felling and girdling upon the liability to insect attack is treated in Chapter X—*Damage to Timber by Insects*.

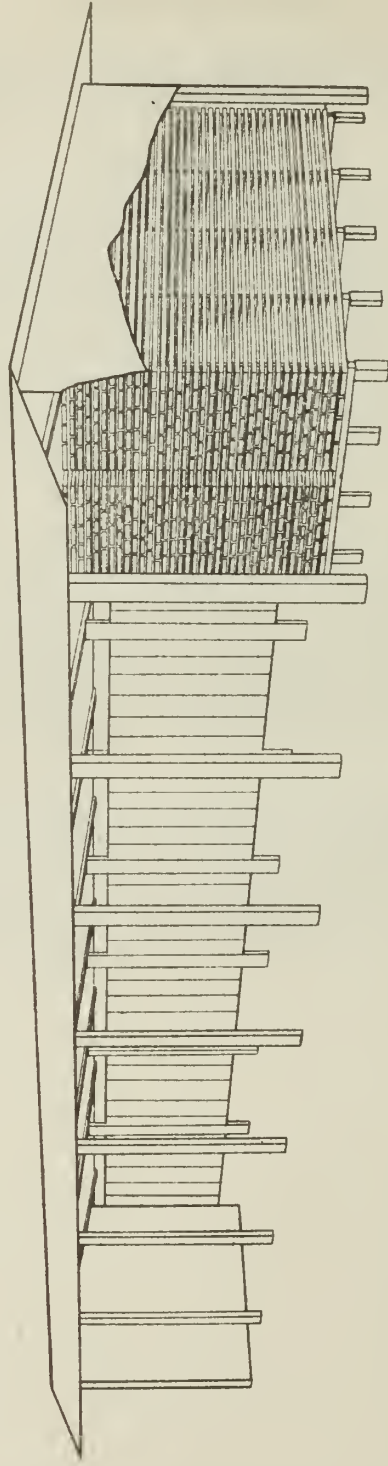
(ii) CONVERSION.

Success in seasoning timber in India by natural methods depends to a large extent upon the time of year that the logs are converted, that is, with respect to the seasons of atmospheric moisture and dryness. Refractory woods should be converted at the time when the atmospheric conditions are least conducive to rapid drying, *i.e.*, during the rainy season or as soon after as possible, so that they will have several months of slow seasoning before the hot, dry weather comes on. Soft, non-durable woods should be converted when the atmospheric conditions are such that the surface of the wood is dried quickly before the fungi spores can develop, *i.e.*, well after the rainy season has passed.

Although the experiments thus far carried out have not furnished definite figures on the subject because of the variables that were involved, it is logical to conclude that considerable depreciation can be prevented by heeding these principles. It is the experience of those accustomed to the conversion of Indian woods that it is impossible to convert certain species in the hot season without excessive cracking before the wood can be seasoned, and that, at other seasons, the same kinds of wood can be converted and seasoned with little or no damage.

The use of seasoning kilns in which the atmospheric conditions can be maintained and regulated according to the requirements of the timber to be seasoned is the most effective means of eliminating the necessity of converting only at certain seasons of the year. The use of seasoning sheds in which the conditions can be controlled within certain limits is of marked effectiveness also.





## CLASS III SHED

A class III shed for moderately refractory woods or for refractory woods in a damp region. This type of shed *must face the North* so that the exposed side will be protected against the sun. See "Seasoning Sheds for Refractory Woods," page 63.

## CHAPTER IX.

**The Treatment of Logs in Storage when Prompt Conversion after Felling is Impossible.**

Emphasis is laid in this note on the necessity of the prompt conversion of logs soon after felling in order to accomplish the seasoning under controlled conditions before the logs have been seriously damaged through splitting, cracking, insects, and fungi. It is important to lay stress on this point, so that, even though the present state of affairs will not permit strict compliance therewith, extraction schemes for the future may be developed to bring about this condition.

The actual improvement of the present practice and the solution of the current problems necessitate a compromise with the ideal, and call for recommendations as to how to proceed to get better results even under present conditions.

It is believed that, after the logs are converted, the recommendations as given for piling practice and means of sheltering the timber are simple of application and can be easily and directly complied with under the present state of affairs. However, under the present conditions of the transport of logs and the manufacture of lumber in India, prompt conversion in many cases is impossible so that the most effective means of accomplishing the seasoning, even by natural methods, cannot be followed in all cases. Really satisfactory results and the full value of the timber can never be realised until these conditions are changed, but it is the writer's opinion that something can be done to bring about better results in spite of existing difficulties.

Improvement depends upon devising means of protecting the logs as much as possible from the time they are felled until they are converted. It is impossible to give a general formula for this protection. Individual cases must be studied in the light of local circumstances, but the general methods of control are as indicated below.

*(i) LOG PONDS.*

Wherever possible, logs which cannot be converted soon after felling should be completely submerged in water. Storage under fresh water (not salt or brackish) prevents splitting, cracking, insect attack, decay, and staining. Alternate wetting and drying results in cracking and decay.

*(ii) STORAGE ON LAND.*

Where the storage under water is impossible, much can be done to improve storage conditions on land.

*(a) Skidding.*—In the timber depôt, in the forest, or along the line of transport, the logs should rest on skids if they are to remain in one place for more than a few days. Skids lift the logs from the

ground and thus retard decay by removing them from contact with debris, soil, moisture, etc., and permit a circulation of air around each log. During prolonged storage the logs should be skidded above the ground at both ends, but for temporary storage one end of the log only need be placed on skids.

(b) *Sheltering*.—Whenever possible, logs should be skidded under the protection of a shed which will shelter them from the sun above and at the sides and break the force of hot dry winds.

When suitable sheds cannot be provided, improvised shelter, such as heavy thatch, should be laid over and slightly above the logs on the skids to protect them from the elements above and at the ends.

This kind of protection is not required in dense forests in the moist regions, but is necessary and should prove easily possible in timber depôts and storage yards, along the lines of transport, and for prolonged shipments by rail during the hot season.

(c) *Girdling*.—(When logs must be stored prior to conversion).

Of the species which probably can be girdled without excessive damage by insects, it is recommended that the following be girdled in the cold weather in most localities, 12—24 months prior to felling:—

*Aegle Marmelos.*  
*Anogeissus latifolia.*  
*Anogeissus pendula.*  
*Careya arborea.*  
*Chloroxylon Swietenia.*  
*Diospyros Melanoxydon.*  
*Grewia tiliaefolia.*  
*Lagerströmia parviflora.*  
*Tectona grandis.*  
*Terminalia Arjuna.*

Unless the local officers have better proof than is provided by these experiments that the timber would be severely damaged by insects in their respective localities, the following species should also be girdled if the logs cannot be converted promptly or stored under water:—

*Bursera serrata.*  
*Cedrela Toona.*  
*Cleistanthus collinus.*  
*Dalbergia Sissoo.*  
*Dillenia pentagyna.*  
*Eugenia Jambolana.*



*Lagerströmia Flos-Reginae.*

*Machilus odoratissima.*

*Melia Azedarach.*

*Michelia Champaca.*

*Morus indica.*

*Schima Wallichii.*

*Stereospermum chelonoides.*

(d) *Barking*.—Removal of the bark from logs held in storage is essential in species which are liable to severe depreciation by insects, sap stain, and decay. However, since barking will increase the damage from cracking and splitting, it is a question of the choice of two evils, action in the matter depending entirely upon the characteristics of the timber dealt with, and the circumstances under which it is handled.

To be at all efficacious against insect attack, the barking should be done within a few days after the trees are felled.

Logs cut from girdled trees do not require barking. The bark of most species is destroyed and falls off during the period of girdling.

In the case of logs cut from ungirdled trees **the following species should be barked immediately after felling**. However, the species which are *starred* should not be barked unless the peeled logs can be well protected from the sun according to recommendations above.

It must be remembered that the species which are *starred* will be liable to severe damage by insects if the bark is left on. The intensity of the damage will be governed largely by the time of year that the trees are felled (*vide* Chapter X—*Damage to Timber by Insects*).

<i>Species.</i>	<i>Locality.</i>
<i>Acer Campbellii</i> ...	... Bengal.
<i>Acrocarpus frazinifolius</i> ...	... Bengal.
<i>Adina cordifolia</i> * ...	... Bombay and Central Provinces.
<i>Albizzia odoratissima</i> * ...	... United Provinces.
<i>Albizzia procera</i> * ...	... Bengal.
<i>Albizzia stipulata</i> ...	... Punjab.
<i>Alstonia scholaris</i> ...	... Malabar.
<i>Anthocephalus Cadamba</i> ...	... Bengal.
<i>Artocarpus Chaplasha</i> ...	... Bengal.
<i>Artocarpus hirsuta</i> ...	... Coorg.
<i>Bombax malabaricum</i> ...	... United Provinces.
<i>Boswellia serrata</i> ...	... Central Provinces and Bihar and Orissa.
<i>Bursera serrata</i> * ...	... Ganjam.
<i>Calophyllum tomentosum</i> ...	... Coorg.
<i>Calophyllum Wightianum</i> * ...	... Coorg.

Species.	Locality.
<i>Cassia Fistula</i> *	... United Provinces.
<i>Cedrela Toona</i>	... Bengal.
<i>Dalbergia latifolia</i>	... Bombay.
<i>Dalbergia Sissoo</i> *	... United Provinces and Punjab.
<i>Dichopsis elliptica</i> *	... Coorg.
<i>Dichopsis polyantha</i> *	... Bengal.
<i>Dillenia pentagyna</i> *	... Bengal.
<i>Dipterocarpus turbinatus</i> *	... Coorg.
<i>Drimycarpus racemosus</i> *	... Bengal.
<i>Duabanga sonneratioides</i> *	... Bengal.
<i>Dysoxylum glandulosum</i> *	... Coorg.
<i>Eugenia gardneri</i> *	... Mangalore.
<i>Eugenia operculata</i> *	... Bengal.
<i>Ficus asperrima</i>	... Malabar.
<i>Frazinus floribunda</i> *	... North-West Frontier Province.
<i>Garuga pinnata</i>	... United Provinces and Ganjam.
<i>Gmelina arborea</i>	... United Provinces.
<i>Hardwickia pinnata</i>	... Mangalore and Coorg.
<i>Holarrhena antidysenterica</i>	... United Provinces.
<i>Holoptelea integrifolia</i>	... United Provinces.
<i>Hopea parviflora</i>	... Coorg and Mangalore.
<i>Hopea Wightiana</i>	... Mangalore.
<i>Hymenodictyon excelsum</i>	... United Provinces.
<i>Juglans regia</i> *	... North-West Frontier Province.
<i>Litsaea polyantha</i>	... Bengal.
<i>Machilus odoratissima</i>	... Bengal.
<i>Melia Azedarach</i> *	... Punjab.
<i>Michelia Champaca</i>	... Bengal.
<i>Odina Wodier</i>	... Central Provinces.
<i>Ougeinia dalbergioides</i> *	... Bombay.
<i>Pinus longifolia</i>	... Punjab.
<i>Pterocarpus Marsupium</i>	... Bombay, Bihar and Orissa and Central Provinces.
<i>Pterospermum acerifolium</i>	... Bengal.
<i>Saccopetalum tomentosum</i>	... United Provinces.
<i>Schrebera swieteniioides</i>	... Central Provinces.
<i>Shorea robusta</i> *	... United Provinces and Bihar and Orissa.
<i>Stephegyne parvifolia</i>	... Central Provinces.
<i>Sterculia urens</i>	... Ganjam.
<i>Sterculia villosa</i>	... Bengal.
<i>Stereospermum chelonoides</i> *	... Bengal.
<i>Stereospermum suaveolens</i>	... United Provinces.
<i>Terminalia Arjuna</i> *	... Central Provinces and United Provinces.
<i>Terminalia belerica</i> *	... Bengal.
<i>Terminalia tomentosa</i> *	... Central Provinces.

<i>Species.</i>	<i>Locality.</i>
<i>Tetrameles nudiflora</i> ...	... Bengal.
<i>Trewia nudiflora</i> ...	... United Provinces.
<i>Vateria indica</i> ...	... Malabar and Coorg.

The following species should not be barked unless the logs can be piled in a godown which shelters them completely from the sun and desiccating winds. These species will be liable to some insect attack with the bark on, but also will be liable to greater damage by cracking and splitting if the bark is removed:—

<i>Species.</i>	<i>Locality.</i>
<i>Aegle Marmelos</i> ...	... United Provinces.
<i>Anogeissus acuminata</i> ...	... Bihar and Orissa.
<i>Anogeissus latifolia</i> ...	... United Provinces and Central Provinces.
<i>Anogeissus pendula</i> ...	... United Provinces.
<i>Bassia latifolia</i> ...	... United Provinces.
<i>Bassia longifolia</i> ...	... Bombay.
<i>Careya arborea</i> ...	... United Provinces, Central Provinces and Ganjam.
<i>Cleistanthus collinus</i> ...	... Central Provinces.
<i>Chloroxylon Swietenia</i> ...	... Central Provinces.
<i>Diospyros Melanoxylon</i> ...	... Central Provinces.
<i>Eugenia Jambolana</i> ...	... United Provinces and Bihar and Orissa.
<i>Grewia tiliæfolia</i> ...	... United Provinces, Central Provinces and Bombay.
<i>Hardwickia binata</i> ...	... Central Provinces.
<i>Lagerströmia Flos-Reginae</i> ...	... Bengal.
<i>Lagerströmia microcarpa</i> ...	... Bombay.
<i>Lagerströmia parviflora</i> ...	... Central Provinces and Bengal.
<i>Morus indica</i> ...	... Punjab.
<i>Phyllanthus Emblica</i> ...	... United Provinces.
<i>Schima Wallichii</i> ...	... Bengal.
<i>Soymida febrifuga</i> ...	... Central Provinces, Bihar and Orissa and Ganjam.
<i>Tectona grandis</i> ...	... Central Provinces.
<i>Terminalia paniculata</i> ...	... Bombay.
<i>Xylia xylocarpa</i> ...	... Bombay.

(e) *Protecting the ends.*—Much of the splitting and cracking of logs can be eliminated if the ends are protected from rapid drying out immediately after cutting. Extra expense is involved, but in the case of valuable woods, at least, the expenditure is justified.

The application of a thick coat of heavy tar, pitch, or other bituminous material is most effective in preventing end drying.

Under circumstances where such material is too costly or unavailable periodic applications of mud and cow dung will be of some effectiveness.

So far as possible, logs on skids should be protected from the sun at the ends by thatch shelters or something equivalent thereto.

## CHAPTER X.

**Damage to Timber by Insects—by C. F. C. Beeson, M.A., F.E.S.,  
D.Sc., Forest Entomologist.**

During the progress of the seasoning experiments described here, the borer-fauna of the timbers under experiment has been investigated by the Forest Entomologist partly from sample logs kept under observation in the Insectary at Dehra Dun, and partly from field-work. The main object of the entomological side of the investigation was to determine the agencies at work, *i.e.*, the species of insects responsible for damage, rather than to discover immediate measures for their control. In fact, the experiments were devised by the Forest Economist to provide satisfactory remedies empirically, and, wherever successful methods have not been obtained, it is evident that no short-cut exists, and a special entomological investigation is required. The Insectary records have revealed the existence of hundreds of species of borers with which we were not previously acquainted, many of which are new to science, but, nevertheless, not necessarily new to commerce. Fresh ideas have been obtained on the distribution, and food habits of the borers and on the conditions under which timbers are liable to attack. Although the mass of data has not yet been finally worked up, a few conclusions having bearing on the practical question of timber seasoning can be made.

In the following pages is presented a tentative classification of the different forms of damage by boring insects to which Indian trees are exposed. This should be read in amplification of the conclusions given below.

- (1) Many species of forest trees are attacked by borers during the life of the tree and the damage is not perceptible until the seasoned timber is worked up. The existence of this form of damage may, therefore, cause a false interpretation to be placed on the value of a particular method of seasoning.
- (2) The distribution of borers that are economic pests, is not necessarily coincident with the distribution of the trees attacked, and consequently a method of seasoning applicable to one locality is not necessarily reliable for another locality.
- (3) The season at which a tree is felled or girdled materially influences its liability to damage by a particular species of borer. The optimum or danger-free period cannot be expressed in general terms, but must be worked out for each species of tree and each variation in its habitat.



- (4) With few exceptions damage by sapwood borers, heartwood or longicorn borers, shot-hole and pin-hole borers can be prevented by removal of the bark or by green conversion immediately after felling.
- (5) The damage is done within a period of 3—6 months from the commencement of attack, and its extent is dependent on the proportions in which the most destructive borers occur; for a pure infestation by one species rarely happens. Beyond this period the extent of the damage is not affected either by the length of time the tree stands girdled, or the timber is held in the log, or by subsequent methods of treatment (*e.g.*, stacking, skidding, sun-curing, water-immersion). It is the work of single broods and is not extended by later broods of the same species.

The following classification gives a general idea of the different types of damage caused by boring insects in India and the conditions under which they are able to work. As a rule we have to deal with borers that do the damage in the grub or caterpillar form, and not as beetles or perfect insects:—

*Borers of living trees.*

Moths—

1. Beehole Borers—

(1) *Cossidae*, (2) *Hepialidae*, (3) *Arbelidae*.

Beetles—

2. Longicorn Borers (*Cerambycidae* and *Lamiidae*).

*Borers of felled or girdled trees.*

Beetles—

1. Longicorn Borers (*Cerambycidae* and *Lamiidae*).
2. Flat-headed Borers (*Buprestidae*).
3. Weevils (*Curculionidae*).
4. *Brenthidae*, *Lymexylonidae*, *Siricidae*, etc.
5. Shot-hole and Pin-hole Borers (*Platypodidae* and *Xyleborinae*).
6. Sapwood Borers.
7. Dry wood Borers (*Bostrychidae*, *Cerambycidae*).

(i) BORERS OF LIVING TREES.

The tunnels of this class of borers are constructed and inhabited during the course of a year. After the emergence of the mature insect the mouths of the galleries connected with the living bark are occluded and overgrown by the wood of subsequent years. Tunnels formed early in the life of the tree thus occur deep in the timber near the pith, and those made later in its life are situated nearer to the

periphery. The health of the tree is in most cases not affected by the attack of the borer, but the accumulated damage to the timber is serious. Frequently the burrows of this class of borers are enlarged or perforated by wood-peckers or extended by ants and termites.

The following are the principal types:—

(a) **Moths.**

1. BEEHOLE BORERS.

This term was originally applied to *Duomitus ceramicus*, a borer of teak in Burma (responsible for an annual loss of ten lakhs), the tunnels of which are universally known as beeholes. Its use may be extended to apply to damage of similar origin in other species of trees.

(1) *Cossidae.*

A caterpillar-borer of this family makes a slightly curved tunnel (usually empty of wood-fibres or dust), from 2 to 10 inches long, circular in cross-section, and varying in diameter from that of a lead pencil to that of one's little finger, *e.g.*

*Tectona grandis* by *Duomitus ceramicus*; *Cassia Fistula* by *Duomitus leuconotus*; *Acer Campellii*, *Juglans regia*, *Litsaea polyantha* by various species of *Duomitus*, *Cossus* and *Zeuzera*.

(3) *Arbelidae.*

Tunnels of caterpillars of this family are often made in the pith or sapwood of young poles, in which they may reach a vertical length of 2 feet, and a diameter of  $\frac{3}{8}$  inch. In older timber the length runs to about 10 inches, *e.g.*

*Tectona grandis* by *Phassus malabaricus* and *Phassus signifer*.

(3) *Arbelidae*

Caterpillars of this group are primarily bark-eaters feeding on the surface of the trunk under the protection of a mat of silk-spun debris, but for retirement and pupation a tunnel is excavated in the wood. When overgrown the boring may simulate a beehole.

(b) **Beetles.**

Whereas the tunnels of the moth-borers are essentially shelter-burrows, those of the beetle-borers are feeding-burrows in which the grub lives permanently. The following types are characteristic of the work of the:—

2. LONGICORN BORERS (*Cerambycidae* and *Lamiidae*).

(1) An extensive system of tunnels running on a whole vertically branching and rejoining, and connected with the bark by short

horizontal ejection holes. The zone occupied by the workings of one grub may reach a length of 3 to 4 feet and the separate tunnels the thickness of one's finger, *e.g.* :—

*Morus indica* by *Apriona cinerea*; *Ficus asperrima*, *Careya arborea* by *Lamiid* (*Batocera* sp.)

(2) A restricted but irregular feeding area, partly under bark and partly in the wood—

- (a) Damage in the form of a canker, resulting in diseased or rotted timber and distortion of the plane of subsequent growth, *e.g.* :—

*Tectona grandis* and *Gmelina arborea* by *Haplohammus cervinus*.

- (b) A close group of short (2") tunnels, *e.g.*—

*Tectona grandis* by *Sagra longicollis* (*Chrysomelidae*).

- (c) Isolated bracket-or C-shaped tunnels, usually filled with fibres and occluded at each end, *e.g.*—

*Tectona grandis* by *Aristobia birmanicum*.

#### (ii) BORERS OF FELLED OR GIRDLED TREES.

When a tree dies or is girdled or felled it is subject to attack by various classes of borers, which require the presence of bark for oviposition or for protection in the initial stages of their development. If the bark is removed from the tree immediately after death the timber is not liable to damage by insects of the following six classes :—

#### Beetles.

##### 1. LONGICORN BORERS (*Cerambycidae* and *Lamiidae*).

The larger longicorn borers feed as grubs in the early stages in the bark and sapwood; as they grow older the sapwood is more or less entirely destroyed and tunnels are extended deeper into the wood, the final tunnel or pupal chamber lying as a rule well within the heartwood at depths up to 6" from the surface. In the case of borers with an annual life-cycle the heartwood tunnel or pupal chamber, 3 to 4 inches long and up to 1 inch in diameter, may be completed within 4 months after the eggs are laid. Borers with a six months cycle may complete their tunnels in 3 months. There is no succession of broods, although delayed emergence normally occurs, *e.g.* :—

*Shorea robusta* by *Hoplocerambyx spinicornis*; *Hardwickia binata*, *Soymida febrifuga* by *Aeolesthes holoserica*; *Dipterocarpus turbinatus* by *Remphan hopei*; *Sterculia villosa* by *Batocera rubus*; and practically all important timbers by various *Cerambycidae* or *Lamiidae*.

2. FLAT-HEADED BORERS (*Buprestidae*).

The grub of the *Buprestidae* is flattened and tape-like in comparison with that of the previous group, and its tunnels are consequently very much narrowed on the shortest diameter. The workings extend irregularly in the sapwood, and deep into the centre of the log in timbers with no marked heartwood; they vary much in width owing to frequent alteration of direction and are characteristically packed tightly with wood-dust. In this class there is a tendency for development of annual cycles to be delayed to 18 or 24 months, with consequent extension of the injurious period, *e.g.*:—

*Acrocarpus fraxinifolius* by *Belionota prasina*; *Pinus longifolia* by *Ancylocheira geometrica*.

3. WEEVILS (*Curculionidae*).

The larger weevil grubs make straight or curved circular tunnels up to  $\frac{3}{8}$ " diameter, that run horizontally across the bole and are normally empty of dust or fibres. The small species extend tunnels  $\frac{1}{8}$ " wide and over in more or less radial directions, *e.g.*:—

*Pinus Khasya*, *Pterocarpus indicus*, *Kydia calycina* by *Sipalus* spp.

4. *Brentidae*, *Lymexylonidae*, *Siricidae*, etc., and other families make elongated galleries in horizontal planes varying in size from small shot to S. S. G., *e.g.*:—

*Bombax malabaricum* by *Cerobates tristriatus*; *Heritiera Fomes* by *Xiphydria heritierae*.

5. SHOT-HOLE AND PIN-HOLE BORERS (*Platypodidae* and *Xyleborinae*).

As their name implies borers of this group make holes of the size of a pin up to that of large shot. The tunnels are constructed in horizontal planes and run parallel with the circumference and occasionally branch. In trees with well-marked heartwood the inner tunnels rarely penetrate more than an inch or two into the heart, but in undifferentiated timber they extend throughout the log. The tunnels are empty of wood-dust and the wood near to them is often stained black. Unless very heavily infested the structural value of the timber is not affected by the work of this group, although its appearance is spoiled for certain uses. *e.g.*:—

*Shorea robusta* by *Diapus furtivus*; *Odina Wodier* by *Platypus solidus*; *Pterospermum acerifolium* by *Xyleborus perforans*, but scarcely any timber trees of importance are immune from attack by *Platypodidae*.

## 6. SAWWOOD BORERS (NUMEROUS FAMILIES).

By far the largest group of borers is that in which the grubs excavate tunnels on the surface of or just within the sapwood, for the



purposes of feeding and pupation. In the majority of cases the depth to which the burrows are carried does not exceed  $1\frac{1}{4}$  inch and in the rest the inside limit is usually the heartwood, *e.g.* :—

*Anogeissus latifolia* by *Olenecamptus curvipes* (Lamiidae); *Grewia tiliaefolia* by *Ceresium leucosticum* (Cerambycidae).

The damage caused by this group is confined to the outer layers of sapwood, although the appearance of a log seen before cutting up, covered with wood-dust and its surface riddled with holes, may be deceptive. The powder-post beetles (*Bostrychidae*) in particular reduce the sapwood to dust, but whatever its breadth their tunnels do not extend into the heartwood, *e.g.* :—

*Dalbergia Sissoo* by *Sinoxylon crassum*.

In those trees without differentiated heartwood the depth to which the galleries of sapwood borers may penetrate rarely exceeds  $1\frac{1}{4}$  inches, but occasionally the whole log is affected. Thus in *Butea frondosa* or *Schrebera swietenoides* the tunnels of *Xylotrechus smei* run deep into the core, whereas in other timbers the same borer is confined to the surface layers.

#### 7. DRY WOOD BORERS (*Bostrychidae*, *Cerambycidae*).

The borers of seasoned or utilized timber are restricted to a few small groups of insects, but the species comprising them are omnivorous. Soft-woods and sapwood are more liable to damage than the heartwood of hard woods. The tunnels are of two principal types :—

- (1) Running irregularly through the wood, closely packed with wood-dust, eventually reducing all but a thin outer shell to dust, *e.g.* :—

*Stromatium barbatum* (Cerambycidae) and *Heterobostrychus aequalis* (Bostrychidae).

- (2) Confined to a narrow ( $\frac{1}{2}$  to 1 inch) zone on the surface of the timber, which is reduced to powder before the inner layers are attacked (*Lyctidae* and *Anobiidae*).

The dry wood borers are more properly speaking borers of utilized wood-products than of wood in process of seasoning. The majority of timbers is unlikely to be attacked after seasoning and methods of prevention need scarcely be considered. Remedial measures include simple treatment with linseed oil, kerosene and creosote, naphthalene in petrol, etc., and antiseptics generally.

Finally under special circumstances old or decayed timber may be used by carpenter bees (*Xylocopa* spp.) as nests.

Damage by white ants is a subject to be considered entirely apart from boring insects.



## (iii) THE LIABILITY OF TIMBERS TO INSECT ATTACK.

The liability of a given species of tree to attack by borers is influenced by several factors, of which the following are the more important:—

- (a) Locality.
- (b) Date of felling and girdling.
- (c) Treatment of logs after felling.

(a) *Locality.*

(1) The factors which determine the natural distribution of a species of forest tree, *e.g.*, climate, altitude, soil, associates, etc., do not necessarily influence in the same way the distribution of the boring insects that attack it. The borer-fauna of a tree is composed of several species of insects, some of which may occur throughout the habitat of the tree, but most of which are restricted only to parts of its habitat. Thus, living teak is attacked by a bee-hole borer only in Burma and by a canker grub (*Haplohammus cervinus*) in Burma and Assam, and not in the peninsula of India. Sal in Bengal and Assam is attacked by a whole series of shot-hole borers, that do not occur in the United Provinces, Central Provinces or in Orissa. The large longicorn borer (*Hoplocerambyx spinicornis*) is found throughout the habitat of sal except in the isolated forests of the Gangetic plains and the dry parts of Orissa and the Central Provinces. Leguminous trees with well-marked heartwood are generally more liable to attack by powder-post beetles (*Bostrychidae*) in dryer than in moister regions.

(2) A species of borer may occur in the same locality as a particular tree species, but its relative abundance is frequently determined by the occurrence of alternate host-trees. A widely distributed shot-hole borer (*Platypus solidus*) is likely to do more damage in a depot containing several rather than one species of trees in which it breeds by preference. On the other hand the species, although polyphagous, may locally be composed of strains having marked preference for one kind of tree to the exclusion of its other normal food-plants.

(b) *Date of felling or girdling.*

The life-cycles of borers vary very much in different groups, from a period of two months or less, in the case of those species with five broods in a year, to 12 months in the case of those with annual life-cycles. The borers with short life-cycles are therefore on the wing at 4 or 5 almost continuous periods of the year, while those with an annual cycle are able to attack the host tree at only one period in the year. The danger-period for liability to attack is further affected by local climates, *e.g.*, in cold or mountainous regions there is a long dead winter season, while in moist or warm regions there is no dead season in winter, but often a period of diminished activity in the hot weather. Variations from the normal annual climate of a place affect the duration or frequency of danger-periods.

For example, the most injurious longicorn borer of *Shorea robusta* is on the wing in the United Provinces from the end of June to beginning of September, its initial appearance and duration being determined by the monsoon; in years of late and scanty rains the danger period is delayed and reduced, whereas in wet years it is earlier and longer. In the moist forests of Bengal and Assam the flight period begins in May in conjunction with the early rains.

The date on which a tree is felled affects its liability to damage by borers in so far that it is likely to be attacked first by those species swarming at or shortly after the date of felling. Thus, in the United Provinces sal felled in October to March is not subject to attack by the large longicorn borer (unless left in the moist shade of the forest), but is infested with shot-hole borers, sapwood borers and small heartwood borers.

Trees felled in the rains and cold weather are attacked by shot-hole borers, e.g., *Diapus furtivus*, and those felled from March to June are not attacked. Trees felled in the hot weather are likely to be attacked by small longicorns: e.g., *Dialeges pauper*, *Diorthus cinereus*, *Aeolesthes holosericea*, but less so in March and April, when the prevalent borers would be *Xylotrechus smeii* and *Sphaerotrypes siwalikensis*, species of no economic importance. The most favourable time to fell sal in order to ensure least damage by borers is in March and April.

In Chota Nagpur two types of sal forest occur interblended, valley sal and hill sal, in the first of which logs lying over during the rains will be attacked by *Hoplocerambyx*, in the second of which unbarked timber present throughout the hot weather is liable to equally serious damage by *Aeolesthes*.

Little is known of the sequence of borers in other trees; but it is evident that, in the case of refractory species, which must be seasoned with the bark on, a practical method of protecting the heartwood can be found in correct felling-dates. The tree can be felled at a period when the bark and outer sapwood will be inhabited and destroyed by surface borers, thus producing conditions unfavourable for the establishment of species that penetrate deeply.

The date of girdling affects the question in an analogous manner, i.e., the liability to damage depending on the period at which the trees begin to die. In general, girdling at the commencement of the hot weather, if it produces rapid death and drying-out of the bark confers immunity, while girdling at the beginning of rains, unless the tree survives till the cold weather, presents the most dangerous conditions.

The most favourable dates for felling and girdling require to be worked out by experiment for different localities, although in many forest divisions local practice or peculiar factors, such as labour supply, may have obtained satisfactory results empirically.

On pages 76-77 is given a list of species for which girdling is recommended as likely to give the most satisfactory results. Information is insufficient to state the most favourable dates for girdling, but there are indications that the following will be satisfactory:—

Girdle in the cold weather	... <i>Anogeissus latifolia</i> . <i>Anogeissus pendula</i> . <i>Grewia tiliaefolia</i> .
Girdle at end of cold weather	... <i>Careya arborea</i> . <i>Terminalia Arjuna</i> . <i>Terminalia tomentosa</i> .
Girdle at any time	... <i>Aegle Marmelos</i> . <i>Chloroxylon Swietenia</i> .* <i>Tectona grandis</i> .

(c) *Treatment of logs after felling.*

The treatment of logs after felling is a factor that works independently of the foregoing conditions and possibly admits of more practical utilisation. It may be stated that where seasoning in the log is contemplated, borer attack is preventable, firstly, by immediate removal of the bark. Unless the bark is present on the log, borers of the following groups are unable to establish themselves:—longicorn borers (*Cerambycidae* and *Lamiidae*); surface or sapwood borers (*Curculionidae*, *Scolytidae*, *Anthribidae*, etc.); shot-hole borers (*Platypodidae*, *Xyleborinae*). There are, naturally, a few exceptions to the rule, e.g., some shot-hole borers can work in fresh moist sapwood and even in charred logs; the specially adapted dry-wood borers, e.g., *Stromatium*, and some *Bostrychidae*, begin to attack as the barked log dries out.

It is obvious, secondly, that damage by borers can be avoided by complete submergence in water during the dangerous periods of the year; and, thirdly, exposure to direct sunlight with frequent turning of logs, that will stand such drastic treatment, is equally effective in checking insect damage.

Green conversion with or without previous removal of the bark confers immunity from attack by all the above-mentioned borers, provided the conversion is immediate, i.e., within a week or two of felling. In most of the records obtained in the present seasoning experiments, the data for borer-attack on planks and beams converted green represent attacks that commenced before conversion took place. Excluding the few instances of the work of dry-wood borers, it may be generally stated that green conversion supplies the best method of preventing damage by borers and that the subsequent treatment of the timber, i.e., vertical or horizontal stacking, immersion in water, shading or sun-drying, scarcely affects the question of further damage

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\* Unattacked in experiments, but safer to girdle during hot weather in South India.

On page 79 are given lists of timbers that should be seasoned with the bark on, if held in the log. Many of these species are liable to serious damage by borers and the risk of attack must be faced. In the table below is a statement (classified according to the arrangement adopted on page 82) of the different groups of boring insects commonly breeding in the more refractory timbers. The table also serves to illustrate the variety of causes of damage, and the range of susceptibility of timbers.

Species of trees.	CLASS OF BORER DAMAGE.											
	Living Tree.					Felled or Girdled Tree.						
	1(1)	1(2)	1(3)	2(1)	2(2)	1	2	3	4	5	6	7
<i>Aegle Marmelos</i> . . . . .	...	...	...	...	...	+	+	...	...	...	+	...
<i>Aibizzia stipulata</i> . . . . .	...	...	+	...	...	...	+	...	...	+	+	+
<i>Anogeissus acuminata</i> . . . . .	...	...	...	...	...	...	...	...	...	...	+	...
<i>Anogeissus latifolia</i> . . . . .	...	...	+	...	...	...	+	+	...	+	+	...
<i>Anogeissus pendula</i> . . . . .	...	...	...	...	...	...	+	...	...	...	+	...
<i>Calophyllum Wightianum</i> . . . . .	...	...	...	...	...	...	...	...	...	...	+	...
<i>Careya arborea</i> . . . . .	...	...	...	p	...	...	...	...	...	+	+	...
<i>Cassia Fistula</i> . . . . .	+	...	...	...	...	...	...	...	...	+	+	+
<i>Cedrela Toona</i> . . . . .	...	...	...	...	...	...	+	...	...	+	+	+
<i>Chloroxylon Swietenia</i> . . . . .	...	...	...	...	...	...	+	...	...	...	...	+
<i>Cleistanthus collinus</i> . . . . .	...	...	...	...	...	...	...	...	...	+	+	...
<i>Dalbergia Sissoo</i> . . . . .	...	...	...	...	...	...	+	+	...	+	+	+
<i>Dichopsis elliptica</i> . . . . .	...	...	...	...	...	+	...	...	...	...	+	...
<i>Dichopsis polyantha</i> . . . . .	...	...	...	...	...	+	...	...	+	+	+	...
<i>Diospyros Melanoxylon</i> . . . . .	...	...	...	...	...	...	...	...	...	...	+	+
<i>Dipierocarpus turbinatus</i> . . . . .	...	...	...	...	...	+	...	...	...	+	+	...
<i>Dysoxylum glandulosum</i> . . . . .	...	...	...	...	...	...	...	...	...	+	...	...
<i>Drimycarpus racemosus</i> . . . . .	...	...	...	...	...	+	...	...	...	+	+	...
<i>Duabanga sonneratioides</i> . . . . .	...	...	...	...	...	+	...	...	...	+	+	...
<i>Eugenia gardneri</i> . . . . .	...	...	...	...	...	...	...	...	...	+	+	...
<i>Eugenia Jambolana</i> . . . . .	...	...	...	...	...	...	+	+	...	+	+	...
<i>Eugenia operculata</i> . . . . .	...	...	...	...	...	...	...	...	...	+	+	...
<i>Fraxinus floribunda</i> . . . . .	...	...	...	...	...	...	...	...	...	...	+	...
<i>Grewia tiliaefolia</i> . . . . .	...	...	...	...	...	...	...	...	...	+	+	+



Species of trees.	CLASS OF BORER DAMAGE.											
	Living Tree.					Felled or Girdled Tree.						
	1(1)	1(2)	1,3)	2(1)	2(2)	1	2	3	4	5	6	7
<i>Hardwickia binata</i> . . .	...	...	...	...	...	+	...	...	+	+	+	+
<i>Juglans regia</i> . . .	+	...	...	...	...	...	...	...	...	...	+	...
<i>Melia Azedarach</i> . . .	...	...	...	...	...	...	...	...	...	...	+	...
<i>Morus indica</i> . . .	...	...	...	+	...	...	...	...	...	...	+	...
<i>Phyllanthus Emblica</i> . . .	...	...	+	..	...	...	...	...	...	...	...	...
<i>Pterocarpus Marsupium</i> . . .	...	...	...	...	...	...	...	...	...	+	+	...
<i>Saccopetalum tomentosum</i> . . .	...	...	...	...	...	+	...	...	...	...	+	...
<i>Shorea robusta</i> . . .	...	...	...	...	...	+	+	+	+	+	+	+
<i>Soyimida febrifuga</i> . . .	...	...	...	...	...	+	+	...	...	+	+	...
<i>Stereospermum chelonoides</i> . . .	...	...	..	...	...	...	...	...	...	+	+	...
<i>Stereospermum suaveolens</i> . . .	...	...	...	...	...	...	...	...	...	...	...	...
<i>Tectona grandis</i> . . .	+	+	...	+	+	...	+	+	...	+	+	..
<i>Terminalia paniculata</i> . . .	...	...	...	...	...	+	...	...	...	+	+	...
<i>Terminalia tomentosa</i> . . .	...	...	...	...	..	+	+	...	+	+	+	+

Measures for the prevention of insect damage, on the condition under which the foregoing timbers must be seasoned, can not be promptly discovered by empirical methods. The remedies must be based on special entomological investigations aimed at the determination of the biology of the borers concerned. The solution of the problem lies in the fixation of the correct dates for felling or girdling, or of periods during which exploitation is safe. These dates are likely to vary from locality to locality.



## SUMMARY AND GENERAL CONCLUSIONS.

(1) Although the most satisfactory solution of many of the seasoning problems in India depends upon kiln seasoning, most of the species dealt with in this study can be seasoned by natural methods with very good results.

(2) Timber, except in the case of a few species, should not be held in the form of logs for seasoning. The amount of splitting by seasoning in the log is considerably greater than by green conversion and the surface cracking is no less. Timber in the log is liable to excessive damage by fungi and insects. Every possible effort should be made to convert logs within a short time after felling.

(3) The majority of the species may best be converted green providing the timber is properly stacked and protected.

(4) Girdling for a period of 18 months reduces appreciably the tendency of the wood to crack after conversion and during final seasoning, but greatly increases the liability to severe damage by insects. The risk is worth taking only in the case of certain refractory species.

(5) When logs cannot be converted soon after felling, special precautions should be taken to protect the logs against splitting, cracking, insects, and fungi.

(6) Immersion in fresh water is the best method of protecting logs awaiting conversion, but does not appear to facilitate the seasoning except in the case of converted pieces of species especially liable to severe discolouration. Converted timber so treated is discoloured and cracks on the surface more than by green conversion directly followed by stacking on land.

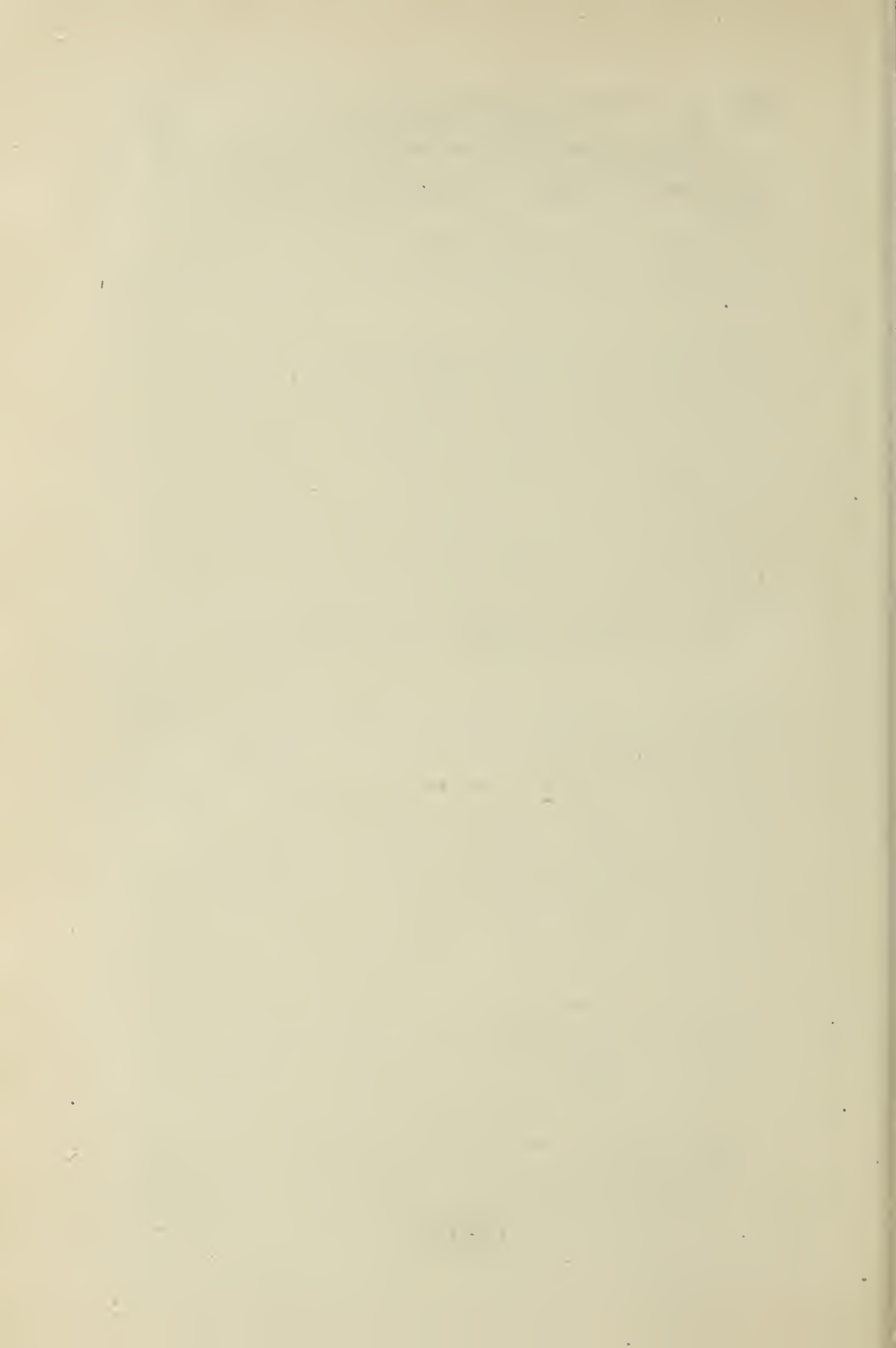
(7) Many species after conversion must be stacked in seasoning sheds so designed as to give protection not only from direct sun and rain, but also from hot, dry winds. The degree of protection required varies with the species and the climatic conditions.

(8) The felling of trees which cannot be converted soon after cutting should not be carried on during the hot season or at the beginning of the rains.

(9) Refractory woods should be converted during or as near the end of the rainy season as possible and not during the hot season unless the converted timber can be put into seasoning kilns or otherwise well protected. Soft, non-durable woods should be converted during the dry season and if possible stacked vertically so as to hasten the seasoning to avoid discolouration and decay.

(10) The moisture content of seasoned wood varies with the season of the year and with the climatic conditions of the locality; in June from 4.8 per cent. in the Hazara Division, North-West Frontier Province to 15.2 per cent. in the Cox's Bazar Division, Bengal.

(11) The rate of seasoning varies with the species, the dimensions into which it is cut and the climatic conditions of the locality. No data are available to indicate the minimum time required by the various woods.



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**APPENDICES.**

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## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	4"	1"	1 1/2"	1 3/4"
1	Acer Campbellii.	Darjeeling Division, Bengal.	Seasoning in log.	...	1-19	8-20	...	2-21	48	...	...	...	19.9	...	...
			Green Conversion.	...	1-19	2-19	...	2-21	231	...	...	...	20.4	...	...
			Water Seasoning.	...	2-19	3-19	6-19	2-21	256	...	...	...	18.4	...	...
			Girdling	...	...	...	...	...	...	...	...	...	...	...	...
2	Acrocarpus fraxinifolius.	Kallimpong Division, Bengal.	Seasoning in log.	...	1-19	9-20	...	2-21	86	...	...	...	12.24	...	...
			Green Conversion.	...	12-18	12-18	...	2-21	188	...	...	...	13.1	...	...
			Water Seasoning.	...	12-18	1-19	4-19	2-21	203	...	...	...	11.6	...	...
			Girdling	2-19	8-20	11-20	...	2-21	386	...	...	...	18.9	...	...
3	Aegle Marmelos.	Gonda Division, United Provinces.	Seasoning in log.	...	12-18	8-20	...	4-21	31	...	...	...	8.3	...	...
			Green Conversion.	...	12-18	1-19	...	4-21	35	...	...	...	8.3	...	...
			Water Seasoning.	...	12-18	1-19	7-19	4-21	38	...	...	...	8.8	...	...
			Girdling	3-19	5-20	8-20	...	4-21	26	...	...	...	7.9	...	...

\* Borers in living trees.

† Due to close piling while wet.

‡ Large borers in sapwood.



## DIX I.

*tabulated by species.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	0	0	2	0	0	17	0	42	50	21*	79	81	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	67	1	1	0	0	0	2	6	7	23*	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	16	0	0	0	0	0	0	6	5	7*	75†	2	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	Not carried out								...	...	...	...
Average									28	0	1	0	0	6	1	18	21				
...	...	...	...	...	...	...	...	...	9	2	0	0	0	0	2	25	22	47‡	49	14§	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	56	2	3	1	0	1	4	4	11	3	15	0	0
12-1	...	...	...	...	...	...	...	...	100	0	0	0	0	0	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	34	11	10	11	1	1	0	37	54	11	6	5	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	45	3	0	2	0	0	0	7	9	32†	0	42§	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									49	4	3	3	0	0	1	15	19				
...	...	...	...	...	...	...	...	...	3	127	3	16	10	0	0	71	198	0	...	0	0
...	...	...	...	...	...	...	...	...	17	101	0	33	0	0	0	0	118	0	...	0	0
...	...	...	...	...	...	...	...	...	0	169	0	17	91	0	0	23	263	0	6	0	0
...	...	...	...	...	...	...	...	...	0	157	0	28	87	0	0	0	236	0	0	0	0
...	...	...	...	...	...	...	...	...	0	141	0	22	0	0	0	19	166	0	0	0	0
...	...	...	...	...	...	...	...	...	0	152	0	51	0	0	0	0	178	13	0	0	0
...	...	...	...	...	...	...	...	...	4	70	0	43	50	0	0	12	138	4	...	0	0
...	...	...	...	...	...	...	...	...	0	117	0	117	51	0	0	0	214	0	...	0	0
Average									3	129	0	41	36	0	0	16	189				

§ In sapwood only.

|| White ants in vertical piling.

† Some blue staining.

## Seasoning defect

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY.)					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT					
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	4"	1"	1 1/2"	1 3/4"	
4	<i>Albizia stipulata</i> .	Kangra Division, Punjab.	Seasoning in log.	..	2-19	8-20	...	7-21	37	...	...	...	7-7	...	...	
			Green Conversion.	...	1-19	1-19	...	7-21	48	...	...	...	8-9	...	...	
				...	2-19	2-19	5-19	7-21	56	...	...	...	8-4	...	...	
				Water Seasoning.	...	2-19	2-19	5-19	7-21	56	...	...	...	8-4	...	...
					...	2-19	2-19	5-19	7-21	56	...	...	...	8-4	...	...
5	<i>Alstonia scholaris</i> .	Wynaad Division, Madras.	Seasoning in log.	...	7-19	7-19 (?)	...	2-22	17	...	...	...	...	...	...	
			Green Conversion.	...	7-19	7-19	...	2-22	28	...	...	...	15-3	...	...	
				...	8-19	8-19	11-19	2-22	36	...	...	...	13-5	...	...	
				Water Seasoning.	...	8-19	8-19	11-19	2-22	36	...	...	...	13-5	...	...
					...	8-19	8-19	11-19	2-22	36	...	...	...	13-5	...	...
6	<i>Anogeisus acuminata</i>	Porahat Division, Bihar and Orissa.	Seasoning in log.	...	10-18	8-20	...	5-21	72	...	...	...	6-4	...	...	
			Green Conversion.	...	10-18	11-18	...	5-21	54	...	...	...	6-5	...	6-8	
				...	10-18	11-18	...	5-21	54	...	...	...	6-5	...	6-8	
				Water Seasoning.	...	10-18	12-18	6-19	5-21	44	...	...	...	6-0	...	...
					...	10-18	12-18	6-19	5-21	44	...	...	...	6-0	...	...

• Large and small borers particularly in sapwood.

† In sapwood.

‡ Small borers in sapwood.

## DIX 1.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING: -			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	0	0	46	0	0	0	0	119	124	89	0	...	0
...	...	...	...	...	...	...	...	...	0	0	41	0	0	0	0	33	56	86	0	...	0
...	...	...	...	...	...	...	...	...	23	0	29	0	0	0	0	75	78	21	0	0	0
...	...	11'8	...	...	...	...	...	...	21	0	21	0	0	0	0	0	16	75	0	0	0
...	...	...	...	...	...	...	...	...	1	0	48	0	0	0	0	86	101	80	16	0	0
...	...	...	...	...	...	...	...	...	0	0	21	0	0	0	0	12	25	75	100	0	0
...	...	...	...	...	...	...	...	...	15	0	56	0	0	0	0	97	115	28	0	0	0
...	...	...	...	...	...	...	...	...	10	0	23	0	0	0	0	40	47	67	0	0	0
Average									9	0	36	0	0	0	0	58	70				
...	...	...	...	...	...	...	...	...	0	0	0	0	0	0	...	6	5	14	24	88	0
...	...	13'5	...	...	...	...	...	...	0	0	0	0	0	0	...	24	18	100	24	41	0
...	...	...	...	...	...	...	...	...	0	0	14	0	0	0	...	43	43	...	58	0	0
...	...	14'5	...	...	...	...	...	...	0	30	0	0	0	0	...	0	10	...	30	0	0
...	...	...	...	...	...	...	...	...	0	8	0	0	0	0	...	143	115	...	3	0	0
...	...	...	...	...	...	...	...	...	0	25	0	0	0	0	...	5	29	...	0	0	0
...	...	...	...	...	...	...	...	...	4	0	4	0	0	0	...	45	37	74	57	4	0
...	...	...	...	...	...	...	...	...	0	0	0	0	0	0	...	0	0	70	93	0	0
Average									1	8	2	6	0	0	...	33	35				
...	...	...	...	...	...	...	...	...	0	0	75	17	0	0	0	77	123	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	4	4	56	7	0	0	0	71	103	17	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	0	39	72	7	0	0	0	...	17	9	68	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	Not carried out	...	...	...	...	...	...	...	...	...	...	...
Average									1	14	68	10	0	0	0	49	108				

§ White ants and large borers.  
 || Small borers.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scanlings.	$\frac{3}{8}$ "	$\frac{5}{8}$ "	1"	1 $\frac{1}{2}$ "	1 $\frac{3}{4}$ "
7	Anogeissus latifolia.	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	6-20	...	3-21	10	...	...	...	4.0	8.3	...
			Green Conversion.	...	5-19	7-19	..	3-21	11	8	...	...	...	7.2	...
			Water Seasoning.	...	5-19	7-19	10-19	3-21	20	10	...	...	...	7.0	6.9
			Girdling.	1-19	7-20	8-20	...	3-21	16	4	...	...	...	4.7	7.7
										11	...	...	...	...	...
	Ditto.	Gonda Division, United Provinces.	Seasoning in log.	...	1-19	8-20	...	4-21	32	...	...	...	7.7	...	...
			Green Conversion.	...	12-18	1-19	...	4-21	38	6	...	...	...	8.4	...
			Water Seasoning.	...	12-18	1-19	7-19	4-21	33	13	...	...	...	7.9	...
			Girdling	3-19	5-20	8-20	...	4-21	33	20	...	...	...	7.7	...
										7	...	...	...	...	...
8	Anogeissus pendula.	Gonda Division, United Provinces.	Seasoning in log.	...	1-19	8-20	...	4-21	12	...	...	...	8.5	...	...
			Green Conversion.	...	1-19	7-19	...	4-21	20	5	...	...	...	8.1	...
			Water Seasoning.	...	1-19	3-19	7-19	4-21	20	4	...	...	...	8.4	...
			Girdling	1-19	3-20	8-20	...	4-21	12	5	...	...	...	7.3	...
										4	...	...	...	...	...

\* Borers.

† Mould due to storage conditions.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2 1/2"	2 3/4"	3"	3 1/4"	3 1/2"	4"	4 1/4"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	40	120	0	30	20	0	0	50	168	10	0	0	0
...	...	...	...	...	...	...	...	...	0	139	0	13	0	0	0	63	193	38	0	0	0
...	...	...	...	...	...	...	...	...	0	182	9	18	100	0	0	27	293	0	0	0	0
...	...	...	...	...	...	8 1	...	...	0	120	0	50	20	0	0	0	168	0	0	0	0
...	...	...	...	...	...	...	...	...	0	270	15	40	10	0	0	20	384	0	0	0	0
...	...	...	...	...	...	...	...	...	0	275	0	50	100	0	0	0	375	0	0	0	0
...	...	...	...	...	...	...	...	...	0	95	13	87	37	0	0	75	232	6	0	0	0
...	...	...	...	...	...	8 5	...	...	0	103	0	73	9	0	0	0	182	55	0	0	0
Average									5	164	5	45	48	0	0	29	248				
...	...	...	...	...	...	...	...	...	3	115	19	40	28	0	0	75	227	0	0	0	0
...	...	...	...	...	...	...	...	...	0	83	0	17	0	51	0	17	155	0	0	0	0
...	...	...	...	...	...	...	...	...	0	210	13	57	24	6	0	8	278	0	0	0	0
...	...	...	...	...	...	...	...	...	0	131	0	38	31	24	0	0	197	0	0	0	...
...	...	...	...	...	...	...	...	...	6	201	9	21	24	0	0	21	252	0	0	0	†
...	...	...	...	...	...	...	...	...	0	175	0	70	15	0	0	0	221	0	0	0	0
...	...	...	...	...	...	...	...	...	6	3	52	42	27	0	0	30	106	0	0	0	0
...	...	...	...	...	...	...	...	...	0	57	0	170	0	0	0	0	142	0	0	0	0
Average									2	122	12	57	19	10	0	19	197				
...	...	...	...	...	...	...	...	...	0	224	0	74	33	0	0	0	286	0	0	0	0
...	...	...	...	...	...	...	...	...	0	180	0	60	0	0	0	0	210	0	0	0	0
...	...	...	...	...	...	...	...	...	0	215	0	60	25	0	0	0	264	0	0	0	60
...	...	...	...	...	...	...	...	...	0	125	0	125	0	0	0	0	188	0	0	0	100
...	...	...	...	...	...	...	...	...	0	115	20	35	20	0	0	0	163	0	0	0	85
...	...	...	...	...	...	...	...	...	0	160	0	160	0	0	0	0	240	0	0	0	100
...	...	...	...	...	...	...	...	...	0	92	33	0	74	0	0	0	172	0	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	125	0	0	0	194	0	0	0	0
Average									0	151	7	64	35	0	0	0	215				

† Due to storage conditions.



## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	$\frac{3}{4}$ "	$\frac{1}{2}$ "	1"	1 $\frac{1}{2}$ "	1 $\frac{3}{4}$ "
9	Artocarpus hirsuta.	Coorg	Seasoning in log.	...	11-19	8-20	...	2-22	41	...	...	...	14.3	...	...
			Green Conversion.	...	11-19	2-20	...	2-22	50	...	...	...	12.0	...	...
			Water Seasoning.	...	11-19	6-20	9-20	2-22	40	...	...	...	14.1	...	...
			Girdling	3-19	8-20	10-20	...	2-22	34	...	...	...	12.0	...	...
									41	...	...	...		...	...
10	Boswellia serrata.	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	6-20	...	3-21	11	...	...	...	...	...	...
			Green Conversion.	...	5-19	7-19	...	3-21	11	...	...	...	...	...	...
			Water Seasoning.	...	5-19	7-19	10-19	3-21	21	...	...	...	...	...	...
			Girdling	2-19	8-20	8-20	...	3-21	46	...	...	...	...	...	...
									10	...	...	...	...	...	...
	Ditto.	Porahat Division, Bihar and Orissa.	Seasoning in log.	...	11-18	8-20	...	5-21	40	...	...	...	15.1	...	...
			Green Conversion.	...	11-18	2-19	...	5-21	71	...	...	...	10.8	...	5.5 ?
			Water Seasoning.	...	11-18	2-19	6-19	5-21	48	...	...	...	7.2	...	...
			Girdling	...	...	...	...	...	...	...	...	...	...	...	...

\* In sapwood.

† White ants.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2½"	3"	3½"	4"	4½"	5"				Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	20	24	0	19	0	0	..	132	133	0	10	20	0
...	...	...	...	...	...	...	...	...	28	21	0	75	2	0	...	27	80	0	7	4	0
...	...	...	...	...	...	...	...	...	42	16	0	8	0	0	..	102	97	0	16	4	8
141	...	...	...	...	...	...	...	...	46	14	0	42	0	0	...	6	40	0	14	0	0
...	...	...	...	...	...	...	...	...	13	85	3	18	3	0	...	84	162	0	0	0	0
...	...	...	...	...	...	...	...	...	42	16	0	33	4	0	...	2	37	0	1	1	0
...	...	...	...	...	...	...	...	...	24	69	0	26	0	0	...	255	273	0	0	3	0
...	...	...	...	...	...	...	...	...	20	33	0	67	0	0	...	24	85	0	10	0	0
Average									29	35	0	36	1	0	..	79	113				
...	...	...	...	...	...	...	...	...	0	0	0	9	0	0	0	0	5	55	0	100	0
...	...	...	...	...	...	...	...	...	0	0	0	7	0	0	0	0	4	93	0	93	0
...	...	...	...	...	...	...	...	...	0	45	0	0	63	0	0	36	119	55	0	9	100
...	...	...	...	...	...	...	...	...	0	40	0	10	50	0	0	0	83	30	0	30	80
...	...	...	...	...	...	...	...	...	0	39	10	48	42	0	0	44	135	52	0	14	0
...	...	...	...	...	...	...	...	...	0	132	0	33	33	0	0	0	173	67	0	0	0
...	...	...	...	...	...	...	...	...	7	13	2	76	17	0	0	39	95	13	0	15	73
...	...	...	...	...	...	...	...	...	0	0	0	70	30	0	0	0	58	20	0	20	100
Average									1	34	2	32	29	0	0	15	84				
...	...	...	...	...	...	...	...	...	0	0	8	5	0	3	0	134	112	18§	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	0	0	56	35	0	11	0	93	140	59§	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	0	6	73	0	0	0	0	132	160	73§	17	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	Not carried out	...	...	...	...	...	...	...	...	...	...	...
Average									0	2	46	13	0	5	0	120	137				

† Small borers.

§ Nature of insect damage unknown.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	2 1/2"	1"	1 1/4"	1 1/2"
11	<i>Bursera serrata.</i>	Ganjam District, Madras.	Seasoning in log.	...	4-19	1-21	...	1-22	42	...	...	...	15.5	...	...
			Green Conversion.	...	4-19	9-19	...	1-22	29	...	...	...	12.9	...	...
				...	...	...	...	...	11	...	...	...	...	...	...
			Water Seasoning.	...	3-19	4-19	7-10	1-22	27	...	...	...	8.9	...	...
				...	...	...	...	...	1	...	...	...	...	...	...
			Girdling .	5-19	1-21	2-21	...	1-22	59	...	...	...	13.6	...	...
12	<i>Calophyllum tomentosum.</i>	Coorg	Seasoning in log.	...	9-18	9-20	...	2-22	75	...	...	...	15.4	...	...
			Green Conversion.	...	11-19	2-20	...	2-22	45	...	...	...	...	...	...
				...	...	...	...	...	41	...	...	...	14.1	...	...
			Water Seasoning.	...	11-19	7-20	10-20	2-22	30	...	...	...	...	...	...
				...	...	...	...	...	52	...	...	...	13.0	...	...
			Girdling .	3-19	10-20	11-20	...	2-22	44	...	...	...	...	...	...
13	<i>Calophyllum Wightianum.</i>	Coorg	Seasoning in log.	...	11-19	8-20	...	2-22	97	...	...	...	16.2	...	...
			Green Conversion.	...	11-19	4-20	...	2-22	41	...	...	...	...	...	...
				...	...	...	...	...	21	...	...	...	13.4	...	...
			Water Seasoning.	...	11-19	6-20	9-20	2-22	23	...	...	...	...	...	...
				...	...	...	...	...	42	...	...	...	15.6	...	...
			Girdling .	3-19	11-20	12-20	...	2-22	31	...	...	...	...	...	...
			Water Seasoning.	...	11-19	6-20	9-20	2-22	43	...	...	...	15.5	...	...
				...	...	...	...	...	41	...	...	...	...	...	...
			Girdling .	3-19	11-20	12-20	...	2-22	78	...	...	...	14.9	...	...
				...	...	...	...	...	35	...	...	...	...	...	...

\* White ants and borers.

† In from the ends of the logs.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.										Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.							PER CENT. OF PIECES SHOWING :—			
2"	2 1/4"	2 1/2"	3"	3 1/4"	3 1/2"	4"	4 1/4"	5"	Surface crack.		Warp.	Cap.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	2	118	7	38	32	0	...	108	247	26	0	0	0
...	...	...	...	...	...	...	...	...	0	114	0	14	0	0	...	72	175	14	0	0	0
...	...	...	...	...	...	...	...	...	0	132	14	72	16	0	...	48	227	0	0	0	0
...	...	...	...	...	...	...	...	...	9	135	0	9	0	0	...	27	160	18	0	0	0
...	...	...	...	...	...	...	...	...	0	217	0	33	46	0	...	47	303	0	0	0	0
...	...	...	...	...	...	...	...	...	0	200	0	0	0	0	...	0	200	0	0	0	0
...	...	...	...	...	...	...	...	...	2	10	5	98	29	0	...	50	202	5	0	0	0
...	...	...	...	...	...	...	...	...	0	109	0	27	9	0	...	54	170	18	0	2	0
Average									2	130	3	36	17	0	...	51	211				
...	...	...	...	...	...	...	...	...	11	43	11	15	1	0	...	282	271	0	4	0	0
...	...	...	...	...	...	...	...	...	51	20	0	16	4	0	...	42	63	0	4	0	0
...	...	...	...	...	...	...	...	...	3	16	0	10	0	0	...	283	233	0	3	0	0
14 5	...	...	...	...	...	...	...	...	20	24	0	50	0	0	...	96	121	0	0	0	0
...	...	...	...	...	...	...	...	...	4	21	6	8	2	0	...	272	235	2	0	0	0
...	...	...	...	...	...	...	...	...	43	11	0	34	0	0	...	42	60	2	0	0	0
...	...	...	...	...	...	...	...	...	8	17	1	0	1	0	...	292	238	1	0	0	0
...	...	...	...	...	...	...	...	...	46	20	0	2	0	0	...	86	96	0	0	0	0
Average									23	23	2	17	1	0	...	174	165				
...	...	...	...	...	...	...	...	...	0	100	5	10	0	0	...	127	204	0	0	0	0
...	...	...	...	...	...	...	...	...	17	31	0	57	4	0	...	30	85	0	0	0	0
...	...	...	...	...	...	...	...	...	2	66	10	17	0	0	...	240	262	0	0	0	0
15 5	...	...	...	...	...	...	...	...	0	51	0	54	43	0	...	178	244	0	0	0	0
...	...	...	...	...	...	...	...	...	7	120	0	13	0	0	...	297	349	0	0	0	0
...	...	...	...	...	...	...	...	...	37	47	0	29	4	0	...	61	110	0	0	0	0
...	...	...	...	...	...	...	...	...	5	79	1	1	1	0	...	238	260	44	0	0	3
...	...	...	...	...	...	...	...	...	11	52	0	43	17	0	...	20	101	26	6	0	0
Average									10	68	2	28	9	0	...	149	202				

† Large borers in heartwood and sapwood.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	4"	1"	1 1/2"	1 1/4"
14	Careya arborea.	Gonda Division, United Provinces.	Seasoning in log.	...	1-19	8-20	...	4-51	67	...	...	...	9.1	...	...
			Green Conversion	...	1-19	1-19	...	4-21	25	...	...	...	...	...	...
			Water Seasoning.	...	1-19	1-19	7-19	4-21	37	...	...	...	8.6	...	...
			Girdling .	3-19	5-20	8-20	...	4-21	19	...	...	...	8.1	...	...
										4	...	...	...	...	...
	Ditto.	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	7-20	...	3-21	4	...	...	...	...	...	...
			Green Conversion.	...	5-19	7-19	...	3-21	16	...	...	...	...	7.1	...
			Water Seasoning.	...	5-19	7-19	10-19	3-21	10	...	...	...	...	7.2	...
			Girdling .	1-19	8-20	8-20	...	3-21	29	...	...	...	7.8	...	7.8
										25	...	...	...	...	...
	Ditto.	Ganjam District, Madras.	Seasoning in log.	...	3-19	1-21	...	1-22	42	...	...	...	12.0	...	...
			Green Conversion.	...	4-19	9-19	...	1-22	24	...	...	...	11.4	...	...
			Water Seasoning.	...	3-19	4-19	7-19	1-22	28	...	...	...	10.9	...	...
			Girdling .	11-19	1-21	2-21	...	1-22	25	...	...	...	11.0	...	...
										0	...	...	...	...	...

\* Borers in sapwood.

† Due to storage conditions.



## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.										Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"			Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	...	1	105	6	55	9	0	0	86	203	4	0	0	0
...	...	...	...	...	...	...	...	...	...	0	115	0	114	43	0	0	0	204	29	0	0	0
...	...	...	...	...	...	...	...	...	...	0	148	0	100	8	0	0	52	243	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	133	0	217	0	0	0	0	242	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	135	0	103	20	0	0	87	267	3	0	11	0
...	...	...	...	...	...	...	...	...	...	0	178	0	100	0	0	0	0	228	0	0	11	0
...	...	...	...	...	...	...	...	...	...	16	26	5	96	16	0	0	105	169	0	0	0	0
...	...	...	...	...	...	...	...	...	...	25	50	0	150	25	0	0	0	144	0	0	0	0
Average										5	111	1	117	15	0	0	41	213				
...	...	...	...	...	...	...	...	...	...	0	300	0	25	50	0	0	0	350	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	187	0	89	63	18	0	12	306	0	6	0	0
...	...	...	...	...	...	...	...	...	...	0	158	69	6	39	12	0	44	287	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	155	0	15	125	60	0	20	331	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	210	30	20	100	0	0	0	318	0	0	0	0
...	...	...	7-9	...	...	...	...	...	...	0	154	0	0	54	123	0	0	318	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	134	59	9	52	17	0	79	198	0	0	0	0
...	...	...	...	...	...	...	...	...	...	8	88	0	52	28	28	0	4	166	0	0	0	0
Average										1	161	20	27	64	32	0	20	284				
...	...	...	...	...	...	...	...	...	...	0	234	11	53	48	0	...	329	552	7	0	2	0
...	...	...	...	...	...	...	...	...	...	0	152	0	103	0	0	...	290	421	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	113	67	136	94	0	...	79	361	0	0	0	0
...	...	...	...	...	...	...	...	...	...	9	39	18	45	0	0	...	81	156	18	0	9	0
...	...	...	...	...	...	...	...	...	...	0	244	142	72	33	0	...	90	486	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	200	27	81	36	0	...	27	308	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	156	104	72	60	0	...	124	408	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average										1	171	53	80	39	0	...	147	390				

† Borers in saw-wood.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	1"	1 1/2"	1 3/4"	1 1/2"	1 3/4"
15	Cassia Fistula.	Gonda Division, United Provinces.	Seasoning in log.	...	2-19	8-20	...	4-21	29	...	...	...	7.7	...	...
			Green Conversion.	...	2-19	3-19	...	4-21	26	...	...	...	8.3	...	...
			Water Seasoning.	...	12-18	1-19	7-19	4-21	29	...	...	...	7.8	...	...
			Girdling .	3-19	4-20	8-20	...	4-21	25	...	...	...	6.5	...	...
										5	...	...	...	...	...
16	Chloroxylon Swietenia.	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	6-20	...	3-21	11	...	...	...	8.1	...	...
			Green Conversion.	...	3-19	7-19	...	3-21	8	...	...	...	7.4	...	11.6
			Water Seasoning.	...	4-19	4-19	7-19	3-21	11	...	...	...	...	...	7.3
			Girdling .	4-19	10-20	11-20	...	3-21	32	...	...	...	6.6	...	...
										15	...	...	...	...	...
17	Cleistanthus collinus.	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	7-20	...	3-21	9	...	...	...	9.6	...	...
			Green Conversion.	...	5-19	7-19	...	3-21	6	...	...	...	7.3	...	8.6
			Water Seasoning.	...	5-19	7-19	10-19	3-21	7	...	...	...	...	...	7.7
			Girdling .	3-19	9-20	9-20	...	3-21	20	...	...	...	9.6	...	...
										19	...	...	...	...	...

\* Borers in sapwood.

† Surface darkening.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBERS OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	Warp.	Cup.	Twist	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	7	74	0	20	17	0	0	48	133	10	0	0	0
...	...	...	...	...	...	...	...	...	40	40	0	20	20	0	0	0	65	0	0	0	0
...	...	...	...	...	...	...	...	...	12	39	0	39	4	0	0	61	107	8	0	0	0
...	...	...	...	...	...	...	...	...	50	30	0	60	10	0	0	0	68	0	0	0	0
...	...	...	...	...	...	...	...	...	0	245	0	79	0	0	0	41	315	0	0	0	0
...	...	...	...	...	...	...	...	...	0	189	0	113	0	0	0	0	246	0	0	0	0
...	...	...	...	...	...	...	...	...	32	8	0	60	0	0	0	8	44	8	0	0	0
...	...	...	...	...	...	...	...	...	40	20	0	20	0	0	0	0	30	20	0	0	0
Average									23	81	0	51	6	0	0	20	126				
...	...	...	...	...	...	...	...	...	0	100	0	9	0	0	0	36	132	0	0	0	0
...	...	...	...	...	...	...	...	...	0	175	0	25	0	0	0	0	188	0	0	0	0
...	...	...	...	...	...	...	...	...	0	164	0	50	0	25	0	0	214	0	†	0	0
...	...	...	...	...	...	9'0	...	...	0	200	0	0	0	0	0	0	200	0	...	0	0
...	...	...	...	...	...	...	...	...	0	145	9	64	18	0	0	36	219	0	†	0	0
...	...	...	...	...	...	...	...	...	0	122	0	77	55	11	0	0	213	0	...	11	0
...	...	...	...	...	...	...	...	...	18	75	0	75	55	9	0	6	167	0	0	0	0
...	...	...	...	...	...	...	...	...	7	47	0	60	39	7	0	13	123	0	0	0	0
Average									3	129	1	44	21	7	0	11	182				
...	...	...	...	...	...	...	...	...	0	144	0	41	0	0	0	0	166	0	0	11	0
9'6	...	...	...	...	...	...	...	...	0	200	0	33	0	0	0	0	217	0	0	67	0
...	...	...	...	...	...	...	...	...	0	215	50	16	48	0	0	0	297	0	0	0	0
...	...	...	...	...	...	10'4	...	...	0	180	0	100	0	0	0	0	230	0	0	0	0
...	...	...	...	...	...	...	...	...	3	229	0	57	43	0	0	0	290	0	0	0	0
...	...	...	...	...	...	...	...	...	0	309	0	0	134	0	0	0	401	0	0	0	0
...	...	...	...	...	...	...	...	...	0	160	20	110	45	0	0	10	271	10	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	88	33	0	0	15	180	5	0	0	0
Average									0	191	9	56	38	0	0	3	257				

† Borers.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantling <sup>2</sup> .	3"	6"	1"	1 1/2"	1 3/4"
18	<i>Dichopsis elliptica</i> .	Coorg	Seasoning in log.	...	9-18	8-20	...	2-22	77	...	...	...	14.9	...	...
			Green Conversion.	...	1-20	5-20	...	2-22	72	...	...	...	14.5	...	...
									40	...	...	...	...	...	...
			Water Seasoning.	...	12-19	6-20	10-20	2-22	54	...	...	...	14.4	...	...
			Girdling	3-19	10-20	11-20	...	2-22	97	...	...	...	15.3	...	...
									44	...	...	...	...	...	...
19	<i>Dichopsis polyantha</i> .	Cox's Bazar Division, Bengal.	Seasoning in log.	...	1-19	6-20	...	6-21	32	...	...	...	...	...	...
			Green Conversion.	...	1-10	2-15	...	6-21	20	...	...	...	...	...	...
									21	...	...	...	...	...	...
			Water Seasoning.	...	1-19	2-19	?	6-21	34	...	...	...	15.5	...	...
			Girdling	...	...	...	...	...	...	...	...	...	...	...	...
									...	...	...	...	...	...	...
20	<i>Dipterocarpus turbinatus</i> .	Coorg	Seasoning in log.	...	11-19	8-20	...	2-22	44	...	...	...	15.5	...	...
			Green Conversion.	...	11-19	4-20	...	2-22	43	...	...	...	15.7	...	...
									37	...	...	...	...	...	...
			Water Seasoning.	...	11-19	6-20	9-20	2-22	48	...	...	...	16.2	...	...
			Girdling	3-19	10-20	10-20	...	2-22	68	...	...	...	15.2	...	...
									47	...	...	...	...	...	...

\* Large borers in heartwood.

† White ants.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.							PER CENT. OF PIECES SHOWING:—				
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Slake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	0	26	20	35	28	0	...	335	341	14	0	1	6
...	...	...	...	...	...	...	...	...	15	96	0	33	18	0	...	88	192	15	0	0	0
...	...	...	...	...	...	...	...	...	3	63	19	78	6	0	...	294	341	0	6	1	3
16'0	...	...	...	...	...	...	...	...	3	118	0	85	8	0	...	184	305	0	0	0	0
...	...	...	...	...	...	...	...	...	0	108	19	37	19	0	...	483	517	0	0	0	2
...	...	...	...	...	...	...	...	...	20	52	0	67	19	0	...	68	151	0	0	0	6
...	...	...	...	...	...	...	...	...	2	36	36	32	19	0	...	381	379	0	1	0	1
...	...	...	...	...	...	...	...	...	5	164	0	61	27	0	...	97	288	0	0	0	0
Average									6	84	12	54	18	0	...	241	314				
...	...	...	...	...	...	...	...	...	3	41	72	0	0	0	0	129	192	6	0	0	0
...	...	...	...	...	...	14'8	...	...	45	41	41	0	0	0	0	37	100	14	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	0	0	0	163	222	0	0	0	0
...	...	...	15'7	...	...	...	...	...	0	99	0	0	0	0	0	48	126	0	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	0	0	0	182	237	0	0	0	0
...	...	...	15'6	...	...	...	...	...	0	100	9	0	0	0	0	32	124	0	0	0	0
Average									8	79	19	0	0	0	0	99	167				
										Not carried out.											
...	...	...	...	...	...	...	...	...	7	20	20	34	31	0	...	210	233	18	0	23	0
...	...	...	...	...	...	...	...	...	3	37	3	22	22	0	...	44	100	0	0	16	22
...	...	...	...	...	...	...	...	...	5	12	19	21	12	0	...	204	199	16	8	8	5
17'2	...	...	...	...	...	...	...	...	22	37	3	60	17	0	...	59	126	0	8	5	0
...	...	...	...	...	...	...	...	...	0	39	33	57	8	2	...	357	368	0	23	0	4
...	...	...	...	...	...	...	...	...	0	75	0	42	14	0	...	50	144	17	28	19	11
...	...	...	...	...	...	...	...	...	1	16	37	52	13	0	...	133	179	3	44	3	7
...	...	...	...	...	...	...	...	...	6	52	0	42	32	0	...	12	106	2	68	0	30
Average									6	36	14	41	19	0	...	134	182				

† White ants and small borers in sapwood.

§ Due to compact piling too near the ground.



## APPENDIX

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).						NUMBER OF PIECES.		PER CENT MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	4"	1"	1 1/4"	1 1/2"	
21	<i>Drimycarpus racemosus</i> .	Cox's Bazar Division, Bengal.	Seasoning in log.	...	1-19	6-20	...	6-21	33	...	...	...	...	...	...	
			Green Conversion.	...	2-9	2-19	...	6-21	27	...	...	...	...	...	...	
			Water Seasoning.	...	11-18	2-19	?	6-21	32	...	...	...	...	...	...	
			Girdling .	...	...	...	...	...	...	...	...	...	...	...	...	
22	<i>Dysoxylum glandulosum</i> .	Coorg .	Seasoning in log.	...	12-19	9-21	...	2-22	57	...	...	...	15.3	...	...	
			Green Conversion.	...	12-19	5-20	...	2-22	46	...	...	...	16.6	...	...	
			Water Seasoning.	...	5-20	8-20	11-20	2-22	45	...	...	...	13.3	...	...	
			Girdling .	3-19	11-20	1-21	...	2-22	166	...	...	...	15.1	...	...	
23	<i>Eugenia gardneri</i> .	South Mangalore Division, Madras.	Seasoning in log.	...	5-19	8-21	...	2-22	82	...	...	...	...	...	18.6	
			Green Conversion	...	5-19	7-19	...	2-22	91	...	...	...	...	...	16.1	
			Water Seasoning.	...	5-19	?	10-19	2-22	41	...	...	...	...	...	16.7	
			Girdling .	8-19	11-20	11-20	...	2-22	86	...	...	...	...	...	...	

\* Blue stain in sapwood.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING :—			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	Warp.	Cup.	Twist.	Spine.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	33	0	45	0	0	0	0	21	50	21	0	0	0
...	...	...	18.2	...	...	18.7	...	...	60	5	25	0	0	0	0	5	28	15	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	0	0	0	70	153	7	0	0	0
...	...	...	14.9	...	...	...	...	...	0	100	0	0	0	0	0	0	100	11	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	0	0	0	124	193	0	0	0	0
16.9	...	...	...	...	...	...	...	...	0	100	0	0	0	0	0	9	107	11	0	0	0
...	...	...	...	...	...	...	...	...	...	Not	carried	out.	...	...	...	...	...	...	...	...	...
Average									16	63	12	0	0	0	0	38	165				
...	...	...	...	...	...	...	...	...	2	53	5	5	0	0	...	285	281	0	47	0	0
...	...	...	...	...	...	...	...	...	41	13	0	17	0	0	...	6	26	0	27	0	3
...	...	...	...	...	...	...	...	...	2	42	0	7	2	0	...	217	210	0	46	0	0
16.2	...	...	...	...	...	...	...	...	31	34	0	14	3	0	...	53	85	0	42	0	0
...	...	...	...	...	...	...	...	...	7	35	7	9	0	0	...	192	189	0	33	0	0
...	...	...	...	...	...	...	...	...	24	60	0	9	6	0	...	9	76	0	9	0	0
...	...	...	...	...	...	...	...	...	14	77	3	2	3	0	...	160	203	0	10	0	0
...	...	...	...	...	...	...	...	...	56	48	0	3	0	0	...	21	65	0	0	0	0
Average									22	45	2	8	2	0	...	120	142				
...	...	...	...	...	...	...	...	...	40	39	0	7	0	0	...	178	176	0	2	7	0
...	...	...	...	...	...	21.2	...	...	0	60	0	0	0	0	...	48	96	0	0	0	0
...	...	...	...	...	...	...	...	...	36	35	0	1	0	0	...	192	186	0	5	0	0
...	...	...	...	...	...	...	...	...	100	0	0	0	0	0	...	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	32	41	5	5	0	0	...	142	154	2	7	0	0
...	...	...	...	...	...	...	...	...	30	70	0	15	0	0	...	55	119	0	0	0	0
16.8	...	...	...	...	...	...	...	...	56	15	7	14	0	0	...	110	110	0	1	0	0
...	...	...	...	...	...	...	...	...	50	51	0	34	0	0	...	17	81	0	0	0	0
Average									43	39	2	10	0	0	...	93	115				

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	4"	1	1 1/2"	1 3/4"
24	Eugenia Jambolana.	Gonda Division, United Provinces.	Seasoning in log.	...	12-18	8-20	...	4-21	68	...	...	...	9.0	...	...
			Green Conversion.	...	12-18	1-19	...	4-21	68	...	...	...	7.5	...	...
			Water Seasoning.	...	12-18	1-19	7-19	4-21	59	...	...	...	...	...	...
			Girdling .	3-19	5-20	8-20	...	4-21	65	...	...	...	6.9	...	...
	Ditto	Sambalpur Division, Bihar and Orissa.	Seasoning in log.	...	10-18	4-20	...	3-21	53	...	...	...	6.5	...	...
			Green Conversion.	...	11-18	1-19	...	3-21	55	...	...	...	6.8	...	...
			Water Seasoning.	...	10-18	2-19	5-19	3-21	56	...	...	...	6.0	...	6.4
			Girdling .	1-19	3-0	?	...	3-21	17	...	...	...	5.7	...	...
25	Eugenia operculata.	Cox's Bazar Division, Bengal.	Seasoning in log.	...	1-19	6-20	...	6-21	53	...	...	...	...	...	...
			Green Conversion.	...	1-19	2-19	...	6-21	37	...	...	...	...	...	...
			Water Seasoning.	...	11-18	1-19	?	6-21	33	...	...	...	...	...	...
			Girdling .	...	...					...	...	...	...	...	...

• Borers.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2 1/2"	2 3/4"	3"	3 1/4"	3 1/2"	4"	4 1/2"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	16	107	1	1	27	0	0	42	162	0	0	0	0
...	...	...	...	...	...	...	...	...	13	76	0	0	25	0	0	2	114	0	0	0	0
...	...	...	...	...	...	...	...	...	31	52	1	16	15	0	0	0	72	0	0	0	0
...	...	...	...	...	...	...	...	...	13	76	0	50	13	0	0	0	111	0	0	0	0
...	...	...	...	...	...	...	...	...	37	62	2	12	8	0	0	17	88	0	0	0	0
...	...	...	...	...	...	...	...	...	22	66	0	0	0	0	0	33	91	0	0	0	0
...	...	...	...	...	...	...	...	...	49	8	0	19	40	0	0	14	58	0	0	0	0
...	...	...	...	...	...	...	...	...	25	25	0	50	0	0	0	0	50	0	0	0	0
Average									26	59	1	19	16	0	0	17	93				
...	...	...	...	...	...	...	...	...	0	72	15	0	23	0	0	90	168	23*	0	19	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	18	58	25	0	24	0	0	20	110	31	0	2	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5'9"	...	...	...	...	...	...	...	...	2	86	41	32	9	0	0	27	160	25	100	2	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	0	53	53	18	41	0	0	24	151	24*	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									5	67	34	13	24	0	0	40	147				
...	...	...	...	...	...	...	...	...	11	40	45	0	0	0	0	123	166	15	0	0	0
...	...	...	...	...	...	...	...	...	19	62	43	0	0	0	0	53	134	14	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	0	0	0	129	197	8	0	0	0
16'2"	...	...	15'1"	...	...	...	...	...	0	95	0	0	0	0	0	9	102	5	0	0	0
...	...	...	...	...	...	...	...	...	0	100	18	0	0	0	0	139	218	0	0	0	0
...	...	...	15'2"	...	...	...	...	...	0	95	9	0	0	0	0	19	116	0	0	0	0
...	...	...	...	...	...	...	...	...	...	Not carried out.	...	...	...	...	...	...	...	...	...	...	...
Average									5	81	19	0	0	0	0	79	156				

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	1"	1 1/2"	1"	1 1/4"	1 3/4"
26	<i>Ficus asperifolia</i> .	Wynaad Division, Madras.	Seasoning in log.	...	7-19	7-19	...	2-22	15	...	...	...	13.8	...	...
			Green Conversion.	...	7-19	7-19	...	2-22	21	...	...	...	17.1	...	...
			Water Seasoning.	...	7-19	7-19	10-19	2-22	16	...	...	...	14.2	...	...
			Girdling	9-19	3-21	3-21	...	2-22	16	...	...	...	16.8	...	...
									10	...	...	...	...	...	...
27	<i>Fraxinus floribunda</i> .	Hazara Division, North-West Frontier Province.	Seasoning in log.	...	11-18	6-20	...	6-21	48	...	...	...	...	...	...
			Green Conversion.	...	5-19	5-10	...	6-21	40	...	...	...	...	...	...
			Water Seasoning.	...	5-19	5-19	9-19	6-21	34	...	...	...	...	...	...
			Girdling	5-19	?	6-20	...	6-21	55	...	...	...	...	...	...
									46	...	...	...	...	...	...
28	<i>Garuga pinnata</i> .	Gonda Division, United Provinces.	Seasoning in log.	...	12-18	8-20	...	4-21	33	...	...	...	8.6	...	...
			Green Conversion.	...	12-18	1-10	...	4-21	64	...	...	...	7.8	...	...
			Water Seasoning.	...	12-18	1-10	7-19	4-21	59	...	...	...	7.8	...	...
			Girdling	3-19	5-20	8-20	...	4-21	37	...	...	...	8.2	...	...
									6	...	...	...	...	...	...

\* Large and small borers in addition to those as of †.

† Large borers in living trees.

‡ Slight damage by borers.

§ White ants.



## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING :—			
2"	2½"	3"	3½"	4"	4½"	5"	5½"	6"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	0	7	0	0	0	0	...	33	32	100	0	100	0
...	...	...	...	...	...	...	...	...	0	33	0	0	0	0	...	11	41	100	0	100	0
...	...	...	...	...	...	...	...	...	10	5	0	5	5	0	...	50	49	33	67	0	0
...	...	15.5	...	...	...	...	...	...	27	69	0	0	7	0	...	7	80	33	7	0	0
...	...	...	...	...	...	...	...	...	19	25	6	6	0	0	...	139	137	31	0	0	0
...	...	...	...	...	...	...	...	...	40	74	0	7	0	0	...	34	103	20	13	0	0
...	...	...	...	...	...	...	...	...	0	0	0	0	0	0	...	137	103	94	50	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	0	0	...	0	100	30	60	0	0
Average									12	39	1	2	2	0	...	51	81				
...	...	...	...	...	...	...	...	...	2	0	44	0	0	0	0	125	127	...	0	0	0
...	...	...	...	...	...	...	...	...	46	0	0	0	0	0	0	63	47	...	0	0	0
...	...	...	...	...	...	...	...	...	13	0	3	0	0	0	0	126	97	0	0	0	0
...	...	...	...	...	...	...	...	...	42	0	5	0	0	0	0	71	57	0	0	0	0
...	...	...	...	...	...	...	...	...	0	0	35	0	0	0	0	144	134	0	0	0	0
...	...	...	...	...	...	...	...	...	54	0	0	0	0	0	0	45	34	0	0	0	0
...	...	...	...	...	...	...	...	...	24	2	42	0	0	0	0	51	72	...	0	0	0
...	...	...	...	...	...	...	...	...	57	13	2	0	0	0	0	41	45	...	0	0	0
Average									30	2	16	0	0	0	0	83	77				
...	...	...	...	...	...	...	...	...	11	31	0	5	63	0	16	60	134	24	...	...	0
...	...	...	...	...	...	...	...	...	11	22	0	55	33	0	33	44	124	22	...	...	0
...	...	...	...	...	...	...	...	...	25	0	0	15	29	0	0	9	36	31	...	0	0
...	...	...	...	...	...	...	...	...	0	88	0	25	13	0	0	0	110	25	0	0	0
...	...	...	...	...	...	...	...	...	17	7	2	24	14	0	0	6	36	66	0	42	0
...	...	...	...	...	...	...	...	...	0	0	0	87	14	0	0	0	54	43	0	57	0
...	...	...	...	...	...	...	...	...	89	0	0	6	5	0	0	3	9	33	3	0	0
...	...	...	...	...	...	...	...	...	17	67	0	33	0	0	0	0	84	67	0	0	0
Average									21	27	0	31	21	0	6	15	73				

|| Sap stained.

\* Incipient decay in sapwood.

\*\* Borers in sapwood and white ants.

†† Due to storage conditions.

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	1"	3"	1"	1 1/2"	1 3/4"
28	Garuga pinnata.	Ganjam District, Madras.	Seasoning in log.	..	3-19	1-21	...	1-22	29	...	...	...	12.2	...	...
			Green Conversion.	...	4-19	9-19	...	1-22	22	...	...	...	11.4	...	...
			Water Seasoning.	...	3-19	4-19	7-19	1-22	30	...	...	...	10.2	...	...
			Girdling	11-19	1-21	2-21	...	1-22	25	...	...	...	11.7	...	...
29	Gmelina arborea.	Gonda Division, United Provinces.	Seasoning in log.	...	1-19	8-20	...	4-21	23	...	...	...	...	...	...
			Green Conversion.	...	1-19	1-19	...	4-21	23	...	...	...	9.6	...	...
			Water Seasoning.	...	1-19	1-19	7-19	4-21	30	...	...	...	7.8	...	...
			Girdling	4-19	5-10	8-20	...	4-21	37	...	...	...	8.3	...	...
30	Grewia filiaefolia.	Gonda Division, United Provinces.	Seasoning in log.	...	4-19	8-20	...	4-21	13	...	...	...	...	...	...
			Green Conversion.	...	4-19	7-19	...	4-21	20	...	...	...	8.3	...	...
			Water Seasoning.	...	4-19	7-19	...	4-21	24	...	...	...	8.2	...	...
			Girdling	...	...	...	...	...	...	...	...	...	...	...	...

• Borers and white ants in sapwood.  
 † In sapwood only prior to conversion.  
 ‡ White ants in sapwood.  
 § Borers in sapwood and white ants.

## DIX I.

*tabulated by species*—contd.

IN PIECES OF VARIOUS THICKNESSES.										Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING :—			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"	6"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	...	0	40	0	37	21	0	...	78	133	38	0	52	0
...	...	...	...	...	...	...	...	...	...	0	100	0	75	0	0	...	0	138	0	0	75	0
...	...	...	...	...	...	...	...	...	...	0	68	5	27	124	0	...	205	332	...	0	+	0
...	...	...	...	...	...	...	...	...	...	0	108	0	33	16	0	...	0	137	33	0	+	0
...	...	...	...	...	...	...	...	...	...	0	106	0	61	23	0	...	19	168	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	200	0	0	0	0	...	0	201	0	0	0	0
...	...	...	...	...	...	...	...	...	...	4	64	4	52	32	0	...	20	132	28	0	+	0
...	...	...	...	...	...	...	...	...	...	0	100	0	0	50	0	...	0	138	50	0	50	0
Average										1	98	1	36	33	0	...	40	172				
...	...	...	...	...	...	...	...	...	...	4	0	0	0	9	0	0	0	7	96	0	0	0
...	...	...	...	...	...	...	...	...	...	57	0	0	29	0	0	0	0	15	11	0	0	0
...	...	...	...	...	...	...	...	...	...	64	7	0	14	15	0	0	0	25	0	0	0	0
...	...	...	...	...	...	...	...	...	...	71	29	0	23	0	0	0	0	43	0	0	0	0
...	...	...	...	...	...	...	...	...	...	33	0	0	7	0	0	0	3	6	60	0	0	0
...	...	...	...	...	...	...	...	...	...	0	57	0	57	0	0	0	0	86	43	0	0	0
...	...	...	...	...	...	...	...	...	...	81	0	0	5	0	0	0	8	9	11	0	0	0
...	...	...	...	...	...	...	...	...	...	57	43	0	0	0	0	0	0	43	...	0	0	0
Average										46	17	0	13	3	0	0	1	29				
...	...	...	...	...	...	...	...	...	...	0	147	0	3	15	0	0	31	186	8	0	0	0
...	...	...	...	...	...	...	...	...	...	0	125	0	50	0	0	0	0	150	0	0	0	0
...	...	...	...	...	...	...	...	...	...	20	40	5	20	35	0	0	5	84	5	0	0	0
...	...	...	...	...	...	...	...	...	...	13	13	0	1.5	0	0	0	0	78	0	0	0	0
...	...	...	...	...	...	...	...	...	...	17	30	8	17	47	0	0	33	105	0	0	0	21
...	...	...	...	...	...	...	...	...	...	13	26	0	33	0	0	0	0	70	0	0	0	50
...	...	...	...	...	...	...	...	...	...	Not carried out.										...	...	...
Average										8	64	2	51	16	0	0	12	112				

|| White ants due to storage conditions.

\* Slight borer attack.

\*\* Due to storage conditions.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scandlings.	3"	4"	1"	1½"	1¾"
30	<i>Græwia tiliaefolia.</i>	South Chanda Division, Central Provinces.	Seasoning in log.	.	12-18	6-20	...	3-21	12	...	...	...	8.4	...	...
			Green Conversion.	...	7-19	7-19	...	3-21	8	...	...	...	...	8.4	...
			Water Seasoning.	...	5-19	7-19	10-19	3-21	5	...	...	...	...	...	8.3
			Girdling.	1-19	7-20	8-20	...	3-21	10	...	...	...	7.2	7.2	...
										10	...	...	...	...	...
											...	...	...	...	...
31	<i>Hardwickia binata.</i>	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	7-20	...	3-21	14	...	...	...	...	10.9	10.3
			Green Conversion.	...	5-19	7-19	...	3-21	11	...	...	...	...	10.2	10.4
			Water Seasoning.	...	5-19	7-19	10-19	3-21	10	...	...	...	...	9.8	11.3
			Girdling.	2-19	8-20	8-20	...	3-21	38	...	...	...	9.7	...	...
										14	...	...	...	...	...
											...	...	...	...	...
32	<i>Hardwickia pinnata.</i>	Coorg.	Seasoning in log.	...	9-18	8-20	...	2-22	63	...	...	...	16.8	...	...
			Green Conversion.	...	12-19	5-20	...	2-22	71	...	...	...	15.4	...	...
			Water seasoning.	...	12-19	5-20	8-20	2-22	64	...	...	...	13.4	...	...
			Girdling.	3-19	8-20	10-20	...	2-22	103	...	...	...	16.5	...	...
										35	...	...	...	...	...
											...	...	...	...	...

\* Borers.

† White ants in sapwood.

## DJX I.

tabulated by species—contd.

IN PIECES OF VARIOUS THICKNESSES.										Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING :—			
2"	2 1/4"	2 1/2"	3"	3 1/4"	3 1/2"	4"	4 1/4"	4 1/2"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	...	0	84	0	67	8	0	0	150	236	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	60	0	90	0	0	0	70	158	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	113	0	63	13	0	0	63	202	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	200	0	25	25	0	0	50	269	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	200	20	60	0	0	0	120	335	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	175	0	0	0	0	0	50	213	0	0	0	0
...	9-2	...	...	...	...	...	...	...	...	10	40	0	40	60	10	0	0	115	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	80	0	30	50	0	0	0	133	0	0	0	0
Average										1	119	3	47	20	1	0	63	208				
...	...	...	...	...	...	...	...	...	...	0	143	0	29	86	0	0	79	281	21	0	0	0
...	...	...	...	...	...	...	...	...	...	0	72	0	77	12	0	0	0	120	78	0	0	0
...	...	...	...	...	...	...	...	...	...	0	135	0	99	9	0	0	128	267	9	0	0	0
...	...	...	...	...	...	...	...	...	...	14	71	0	159	0	0	0	0	151	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	130	0	180	0	0	0	50	258	0	0	0	0
...	...	...	...	...	...	...	...	...	...	0	70	0	200	0	0	0	0	170	0	0	0	0
...	...	...	...	...	...	...	...	...	...	5	59	0	50	63	6	0	0	137	71	0	0	0
...	...	...	...	...	...	...	...	...	...	0	78	0	92	0	0	0	0	124	70	0	0	0
Average										2	95	0	111	21	1	0	32	191				
...	...	...	...	...	...	...	...	...	...	5	38	6	33	5	0	...	143	170	16	5	27	0
...	...	...	...	...	...	...	...	...	...	11	71	0	72	2	0	...	64	157	2	11	18	0
...	...	...	...	...	...	...	...	...	...	25	14	6	19	1	0	...	55	70	1	18	3	1
17-7	...	...	...	...	...	...	...	...	...	3	39	6	73	0	0	...	0	70	16	38	24	0
...	...	...	...	...	...	...	...	...	...	0	52	11	53	2	0	...	256	281	8	11	11	6
...	...	...	...	...	...	...	...	...	...	25	38	0	63	4	0	...	45	104	4	9	24	4
...	...	...	...	...	...	...	...	...	...	19	20	18	14	1	0	...	143	149	14	7	8	0
...	...	...	...	...	...	...	...	...	...	31	54	6	20	0	0	...	64	117	26	6	26	9
Average										15	41	7	44	2	0	...	96	140				

++ Borers in sapwood.  
 § In sapwood.



## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	3"	1"	1 1/2"	1 3/4"
32	Hardwickia pinnata.	South Mangalore Division, Madras.	Seasoning in log.	...	4-10	10-20	...	2-22	...	...	...	...	...	...	...
			Green Conversion.	...	4-10	6-10	...	2-22	30	...	...	...	...	...	13.4
			Water Seasoning.	...	4-10	?	10-19	2-22	43	...	...	...	...	...	15.5
			Girdling.	4-19	10-20	1-21	...	2-22	157	...	...	...	...	14.1	...
										0	...	...	...	...	...
33	Holarrhena antidysenterica.	Gonda Division, United Provinces.	Seasoning in log.	...	1-19	8-20	...	4-21	12	...	...	...	6.4	...	...
			Green Conversion.	...	1-19	7-19	...	4-21	16	...	...	...	9.5	...	...
			Water Seasoning.	...	1-19	7-19	(?)	4-21	9	...	...	...	8.9	...	...
			Girdling.	1-19	3-20	8-20	...	4-21	8	...	...	...	6.0	...	...
										2	...	...	...	...	...
34	Holoptelea integrifolia.	Gonda Division, United Provinces.	Seasoning in log.	...	1-19	8-20	...	4-21	62	...	...	...	7.1	...	...
			Green Conversion.	...	1-19	3-19	...	4-21	44	...	...	...	7.0	...	...
			Water Seasoning.	...	1-19	3-19	7-19	4-21	57	...	...	...	7.6	...	...
			Girdling.	2-19	4-20	8-20	...	4-21	37	...	...	...	7.3	...	...
										7	...	...	...	...	...

\* Mostly white ants on surface.

† Borers in heartwood.

‡ Borers probably due to storage in log.

§ White ants.

|| Due to storage conditions.

¶ Borers.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent. sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT. OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	0	37	21	13	0	0	...	99	136	26	0	3	85
...	...	...	...	...	...	15.5	...	...	0	135	3	12	0	0	...	30	166	72	0	9	94
...	...	...	...	...	...	...	...	...	0	2	2	3	0	0	...	65	55	7	0	5	84
...	...	...	...	...	...	...	...	...	0	121	0	0	3	0	...	8	133	88	0	33	54
...	...	...	...	...	...	...	...	...	0	0	15	2	6	0	...	29	39	81	1	0	97
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									0	50	8	7	3	0	...	46	106	...	...	...	...
...	...	...	...	...	...	...	...	...	50	33	0	0	3	0	0	0	39	0	0	0	0
...	...	...	...	...	...	...	...	...	0	0	0	0	100	0	0	0	75	0	0	0	0
...	...	...	...	...	...	...	...	...	25	31	0	13	0	0	0	6	42	13	25	0	0
...	...	...	...	...	...	...	...	...	25	75	0	75	0	0	0	0	113	...	...	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	44	89	0	0
...	...	...	...	...	...	...	...	...	0	66	0	33	0	0	0	0	83	33	67	0	0
...	...	...	...	...	...	...	...	...	13	13	0	0	0	0	0	0	13	75	0	0	0
...	...	...	...	...	...	...	...	...	0	0	0	0	0	0	0	0	100	0	0	0	6
Average									14	27	0	15	14	0	0	1	46	...	...	...	...
...	...	...	...	...	...	...	...	...	26	27	0	3	43	0	0	30	83	5	0	16	0
...	...	...	...	...	...	...	...	...	0	126	0	75	13	0	39	0	193	0	0	50	0
...	...	...	...	...	...	...	...	...	5	7	0	25	57	0	0	5	66	16	0	0	95
...	...	...	...	...	...	...	...	...	11	44	0	11	66	0	0	0	90	0	0	0	89
...	...	...	...	...	...	...	...	...	35	0	4	13	52	0	0	9	55	7	0	0	0
...	...	...	...	...	...	...	...	...	30	90	0	70	0	0	0	10	133	0	0	0	0
...	...	...	...	...	...	...	...	...	8	0	0	46	37	0	0	49	88	0	59	0	0
...	...	...	...	...	...	...	...	...	14	42	0	71	14	0	0	28	109	0	0	0	0
Average									16	42	1	39	35	0	5	16	103	...	...	...	...

\*\* Borers in sapwood.

++ Incipient decay in heartwood and sapwood.

+++ White ants and mould due to storage conditions.

|||| Black discoloration possibly decay.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	4"	1"	11"	13"
35	Hopea parviflora.	Coorg	Seasoning in log.	...	9-18	9-20	...	2-22	83	...	...	...	15.3	...	...
				...						41	...	...	...	...	...
			Green Conversion.	...	5-20	8-20	...	2-22	53	...	...	...	14.7	...	...
				...						40	...	...	...	...	...
			Water Seasoning.	...	8-20	8-20	11-20	2-22	43	...	...	...	14.8	...	...
				...						27	...	...	...	...	...
	Ditto	South Mangalore Division, Madras.	Girdling .	4-19	12-20	12-20	...	2-22	50	...	...	...	15.9	...	...
										32	...	...	...	...	...
			Seasoning in log.	...	5-10	8-21	...	2-22	65	...	...	...	...	...	20.8
				...						10	...	...	...	...	...
			Green Conversion.	...	5-19	7-19	...	2-22	47	...	...	...	...	...	14.0
				...						11	...	...	...	...	...
36	Hopea Wightiana.	South Mangalore Division, Madras.	Water Seasoning.	...	5-19	(?)	11-19	2-22	70	...	...	...	...	...	12.1
				...						19	...	...	...	...	...
			Girdling .	6-19	11-20	11-20	..	2-22	94	..	...	...	...	...	16.1
										6	...	...	...	...	...
			Seasoning in log.	..	5-19	1-21	...	2-22	68	...	...	...	...	15.9	...
				...						0	...	...	..	...	...
	Hopea Wightiana.	South Mangalore Division, Madras.	Green Conversion.	...	5-19	8-19	...	2-22	32	...	...	...	...	...	16.2
				...						16	...	...	...	...	...
			Water Seasoning.	...	6-19	(?)	11-19	2-22	34	...	...	...	...	...	13.4
				...						9	...	...	...	...	...
			Girdling .	6-19	10-20	12-20	...	2-22	...	...	...	...	...	...	15.6

\* Large borers in sapwood and outer heartwood.

† White ants.

‡ In sapwood.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.							PER CENT. OF PIECES SHOWING:—				
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	18	60	2	2	1	0	...	140	168	13	20	0	0
...	...	...	...	...	...	...	...	...	49	71	0	0	0	0	...	6	76	17	0	0	0
...	...	...	...	...	...	...	...	...	25	75	4	0	2	0	...	172	200	2	4	4	0
13'9	...	...	...	...	...	...	...	...	40	62	0	3	11	0	...	3	74	0	0	0	0
...	...	...	...	...	...	...	...	...	19	53	0	0	0	0	...	154	169	16	0	0	0
...	...	...	...	...	...	...	...	...	41	41	0	19	4	0	...	0	54	19	0	0	0
...	...	...	...	...	...	...	...	...	18	54	0	0	0	0	...	88	120	28	0	0	0
...	...	...	...	...	...	...	...	...	53	31	0	3	0	0	...	0	33	25	0	0	0
Average									33	56	1	3	2	0	...	70	113				
...	...	...	...	...	...	...	...	...	52	34	0	0	0	0	...	118	123	0	0	0	0
...	...	...	...	...	...	23'3	...	...	60	40	0	0	0	0	...	40	70	0	0	0	0
...	...	...	...	...	...	...	...	...	45	33	0	0	4	0	...	59	80	0	6	0	0
...	...	...	...	...	...	...	...	...	55	18	0	9	0	0	...	0	23	9	18	0	0
...	...	...	...	...	...	...	...	...	69	27	0	0	0	0	...	48	63	0	6	0	0
...	...	...	...	...	...	...	...	...	58	26	0	16	11	0	...	0	42	0	11	0	0
...	...	...	...	...	...	...	...	...	5	18	0	0	2	0	...	15	31	80	0	0	0
...	...	...	...	...	...	...	...	...	17	50	0	0	0	0	...	17	63	33	0	0	0
Average									45	31	0	3	2	0	...	37	62				
...	...	...	...	...	...	...	...	...	12	61	0	0	0	0	...	74	117	0	28	...	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	56	19	0	0	0	0	...	9	26	19	6	0	0
...	...	...	...	...	...	...	...	...	38	19	0	0	0	0	...	0	19	38	19	0	0
...	...	...	...	...	...	...	...	...	47	44	0	3	0	0	...	27	66	3	0	0	0
...	...	...	...	...	...	...	...	...	56	33	0	11	0	0	...	0	39	22	0	0	0
...	...	...	...	...	...	...	...	...	...	Use less	timber	due	to	decay and	insects						
Average									42	35	0	3	0	0	...	22	53				

§ In sapwood due to a leaky roof.  
 || Incipient decay.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT. MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	$\frac{3}{8}$ "	$\frac{5}{8}$ "	1"	1 $\frac{1}{2}$ "	1 $\frac{3}{4}$ "
37	Hymenodictyon excelsum.	Gonda Division, United Provinces.	Seasoning in log.	...	12-18	8-20	...	4-21	51	...	...	...	8.4	...	...
			Green Conversion.	...	12-18	1-19	...	4-21	47	6	...	...	8.5	...	...
			Water Seasoning.	...	12-18	1-19	7-19	4-21	43	8	...	...	7.2	...	...
			Girdling .	3-19	5-20	8-20	...	4-21	29	17	...	...	8.1	...	...
										5	...	...	...	...	...
38	Juglans regia.	Hazara Division, North-West Frontier Province.	Seasoning in log.	...	12-18	6-20	...	6-21	50	...	...	...	...	...	...
			Green Conversion.	...	4-19	5-19	...	6-21	52	32	...	...	4.8	...	...
			Water Seasoning.	...	4-19	5-19	8-19	6-21	68	21	...	...	5.0	...	...
			Girdling .	11-18	11-19	12-19	...	6-21	79	11	...	...	6.0	...	...
										22	...	...	...	...	...
39	Litsaea polyantha.	Buxa Division, Bengal.	Seasoning in log.	...	2-19	5-20	...	2-21	57	...	...	...	...	...	12.3
			Green Conversion.	...	1-19	2-19	...	2-21	72	0	...	...	13.5	...	...
			Water Seasoning.	...	1-19	2-19	6-19	2-21	40	14	...	...	12.0	...	12.0
			Girdling .	3-19	5-20	7-20	...	2-21	80	13	...	...	...	...	12.8
										0	...	...	...	...	...

\* White ants due to storage.

† Slight blue stain.



## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.								PER CENT. OF PIECES SHOWING:—			
2"	2½"	2¾"	3"	3¼"	3½"	4"	4¾"	5"		Surface cracks.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	24	24	2	14	37	0	2	57	104	0	0	0	0
...	...	...	...	...	...	...	...	...	0	51	0	66	33	0	17	34	143	0	0	0	0
...	...	...	...	...	...	...	...	...	32	4	0	23	62	0	0	6	67	0	0	0	0
...	...	...	...	...	...	...	...	...	0	75	0	50	25	0	0	0	119	0	0	0	0
...	...	...	...	...	...	...	...	...	23	2	0	23	58	0	9	31	85	12	0	0	0
...	...	...	...	...	...	...	...	...	15	24	0	89	18	0	6	0	85	12	0	0	0
...	...	...	...	...	...	...	...	...	38	0	0	40	16	0	0	27	52	0	...	0	0
...	...	...	...	...	...	...	...	...	20	60	0	100	20	0	0	49	155	0	...	0	0
Average									19	30	0	51	34	0	4	24	101				
...	...	...	...	...	...	...	...	...	6	0	34	0	0	0	0	148	137	...	0	0	0
...	...	...	...	...	...	...	...	...	19	0	0	0	0	0	0	99	74	...	0	0	0
...	...	...	...	...	...	...	...	...	21	0	31	0	0	0	0	96	95	0	0	0	0
...	...	...	...	...	...	...	...	...	58	0	0	0	0	0	0	62	47	0	0	0	0
...	...	...	...	...	...	...	...	...	37	0	3	0	0	0	0	81	63	0	0	0	0
...	...	...	...	...	...	...	...	...	56	0	0	0	0	0	0	127	95	0	0	0	0
...	...	...	...	...	...	...	...	...	38	0	0	0	0	0	0	76	57	...	0	0	0
...	...	...	...	...	...	...	...	...	56	0	0	0	0	0	0	96	72	...	0	0	0
Average									29	0	9	0	0	0	0	98	80				
...	...	...	...	...	...	...	...	...	0	4	0	18	0	0	0	4	16	88§	18	60	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13.1	...	...	...	...	...	...	...	...	11	11	3	15	1	1	2	11	32	58	4	0	0
...	...	...	14.0	...	...	...	...	...	29	14	0	7	0	0	14	14	35	57§	0	0	0
13.2	...	...	...	...	...	...	...	...	10	41	0	8	3	0	8	33	76	0	53	13	0
...	...	...	...	...	...	...	...	...	8	85	0	0	0	0	0	8	91	...	0	8	0
...	...	...	...	...	...	...	...	...	3	13	0	31	0	25	0	6	58	65§	85	9	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									10	28	1	13	1	4	4	13	51				

† Slight damage by borers.

§ Borers and white ants former in living trees.

## APPEN

*Seasoning defects*

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF P E C E S.		PER CENT. MOISTURE CONTENT					
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	1"	2"	3"	4"	5"	
40	Melia Azedarach.	Lahore Division, Punjab.	Seasoning in log.	...	2-19	8-20	...	1-21	38	...	...	...	7.9	...	...	
			Green Conversion.	...	2-19	2-19	...	1-21	25	...	...	...	8.3	...	...	
				...	2-19	2-19	6-19	1-21	47	...	...	...	7.6	7.9	...	
				...	2-19	2-19	...	1-21	23	...	...	...	...	...	...	
				Girdling .	2-19	8-20	8-20	...	1-21	52	...	...	...	8.1	..	...
			...	...	...	...	...	25	...	...	...	...	...	...		
41	Odina Wodier.	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	6-20	...	3-21	11	...	...	...	...	...	23.3	
			Green Conversion.	...	5-19	7-19	...	3-21	10	...	...	...	...	8.2	...	
				...	5-19	7-19	10-19	3-21	19	...	...	...	...	10.0	9.3	
				...	5-19	7-19	...	3-21	9	...	...	...	...	...	...	
				Girdling .	1-19	7-20	8-20	...	3-21	18	...	...	...	...	15.2	...
			...	...	...	...	...	6	...	...	...	...	...	...		
42	Phyllanthus Emblica.	Gonda Division, United Provinces.	Seasoning in log.	...	4-19	8-20	...	4-21	15	...	...	...	8.4	...	...	
			Green Conversion.	...	4-19	7-19	...	4-21	6	...	...	...	...	...	...	
				...	4-19	7-19	(?)	4-21	26	...	...	...	...	9.4	...	...
				...	4-19	7-19	...	4-21	2	...	...	...	...	...	...	
				Water Seasoning.	...	4-19	7-19	(?)	4-21	21	...	...	...	...	9.6	...
			Girdling .	4-19	6-20	8-20	...	4-21	2	...	...	...	...	...	...	
...	...	...	...	...	...	6	...	...	...	...	...	...	...			

\* Borers and white ants.

† Sap rot.

‡ White ants.

§ In sapwood.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.								Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.								PER CENT OF PIECES SHOWING :—				
2"	2 1/2"	2 3/4"	3"	3 1/2"	3 3/4"	4"	4 1/2"		5"	Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	58	0	0	0	0	0	0	45	34	0	0	0	0
...	...	...	9'1	10'2	...	...	...	...	92	0	0	0	0	0	0	4	3	0	0	0	0
...	...	...	...	...	...	...	...	...	64	22	14	0	0	0	0	11	41	0	0	0	0
...	8'5	...	7'6	...	7'8	...	...	...	79	3	13	0	0	0	0	8	19	0	0	0	0
...	...	...	...	...	...	...	...	...	64	4	11	0	0	0	0	8	18	0	0	0	0
...	8'4	...	7'8	...	.	...	...	...	74	0	4	0	0	0	0	8		0	0	0	0
...	...	...	...	...	...	...	...	...	90	2	6	0	0	0	0	0	7	0	0	0	0
...	...	...	9'4	...	...	...	...	...	100	0	0	0	0	0	0	0	0	0	0	0	0
Average								78	4	6	0	0	0	0	11	16					
...	...	...	...	...	...	...	...	...	0	36	0	36	54	0	0	18	108	91	0	100	0
...	...	...	...	...	...	...	...	...	0	120	0	141	7	0	0	0	196	100	0	100	0
...	...	...	...	...	...	...	...	...	0	40	10	20	110	0	0	60	185	10	90	0	0
...	...	...	...	...	...	8'9	...	...	0	140	0	60	20	60	0	0	275	20	90	0	0
...	...	...	...	...	...	...	...	...	0	94	11	26	100	0	0	16	202	37	58	0	0
...	...	...	...	...	...	...	...	...	0	167	0	22	132	44	0	0	321	33	11	0	0
...	...	...	...	...	...	...	...	...	0	22	0	44	73	0	0	33	124	50	22	28	0
...	...	...	...	...	...	...	...	...	0	150	0	0	0	51	0	0	201	...	100	...	0
Average								0	96	3	44	62	23	0	16	202					
...	...	...	...	...	...	...	...	...	0	234	0	0	39	0	0	0	263	20	0	0	0
...	...	...	...	...	...	...	...	...	0	250	0	84	0	0	0	0	292	33	0	0	0
...	...	...	...	...	...	...	...	...	0	208	8	24	106	0	0	0	306	15	0	0	0
...	...	...	...	...	...	...	...	...	0	200	0	0	200	0	0	0	350	0	0	0	0
...	...	...	...	...	...	...	...	...	0	140	0	15	91	0	0	57	268	0	0	0	43
...	...	...	...	...	...	...	...	...	0	100	0	100	100	0	0	0	225	0	0	0	...
...	...	...	...	...	...	...	...	...	0	152	50	17	50	0	0	0	242	...	0	0	0
...	...	...	...	...	...	...	...	...	0	117	0	85	17	0	51	0	198	33	0	0	0
Average								0	176	7	41	77	0	6	7	268					

|| Borers in sapwood.

\* Borers partly those in living tree.

\*\* Due to storage conditions.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	3"	3 1/2"	4"	4 1/2"	5"
43	Pterospermum acerifolium.	Kalinpong Division, Bengal.	Seasoning in log.	...	12-18	9-20	..	2-21	66	...	...	...	11'8	...	...
										0	...	...	...	...	...
			Green Conversion.	...	12-18	1-19	...	2-21	82	...	...	...	11'1	...	...
										0	...	...	...	...	...
			Water Seasoning	...	12-18	1-19	4-19	2-21	77	...	...	...	11'8	...	...
										19	...	...	...	...	...
			Girdling .	2-19	8-20	11-20	...	2-21	112	..	...	...	11'3	...	...
										0	...	...	...	...	...
44	Saccopetalum tomentosum.	Gonda Division, United Provinces.	Seasoning in log.	...	2-19	8-20	...	4-21	31	...	...	...	8'2	...	...
										6	...	...	...	...	...
			Green Conversion.	...	2-19	1-20	...	4-21	29	...	...	...	8'4	...	...
										9	...	...	...	...	...
			Water Seasoning.	...	12-18	1-19	7-19	4-21	26	...	...	...	8'0	...	...
										9	...	...	...	...	...
			Girdling .	3-19	4-20	8-20	..	4-21	50	...	...	...	8'0	...	...
										6	...	...	...	...	...
45	Schrebera swietenoides.	South Chanda Division, Central Provinces.	Seasoning in log.	...	12-18	6-20	...	3-21	10	...	...	...	7'1	...	...
										8	...	...	...	...	...
			Green Conversion.	...	5-19	7-19	...	3-21	12	...	...	...	...	8'0	8'5
										4	...	...	...	...	...
			Water Seasoning.	...	5-19	7-19	10-19	3-21	18	...	...	...	...	8'0	8'5
										1	...	...	...	...	...
			Girdling .	2-19	7-20	7-20	...	3-21	13	...	...	...	7'9	8'1	...
										14	...	...	...	...	...

\* Small borers in heartwood and sapwood.

† Slight borer attack, mostly white ants.

‡ Discoloration in sapwood probably decay too.

## DIX I.

tabulated by species—contd.

IN PIECES OF VARIOUS THICKNESSES.									Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.							PER CENT OF PIECES, SHOWING:—				
2"	2½"	2¾"	3"	3½"	3¾"	4"	4¾"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	5	0	2	0	0	0	0	46	36	82*	9	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	38	8	0	1	0	0	0	29	30	34†	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	35	15	6	3	0	1	0	38	51	12	0	0	0
13*3	...	...	...	...	...	...	...	...	16	85	0	16	0	0	0	0	93	11†	0	0	0
...	...	...	...	...	...	...	...	...	36	0	3	0	0	0	0	28	23	42*	3	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									26	22	2	4	0	0	0	28	47				
...	...	...	...	...	...	...	...	...	0	36	13	22	46	0	0	165	215	16	84	0	0
...	...	...	...	...	...	...	...	...	0	0	84	50	33	0	0	0	113	17	83	17	0
...	...	...	...	...	...	...	...	...	0	20	7	47	38	0	0	13	87	7	0	0	100
...	...	...	...	...	...	...	...	...	0	44	0	11	44	0	0	0	83	0	0	0	100
...	...	...	...	...	...	...	...	...	12	43	4	46	27	0	0	43	122	12	0	0	0
...	...	...	...	...	...	...	...	...	0	111	0	56	22	0	0	0	156	0	0	0	0
...	...	...	...	...	...	...	...	...	12	118	8	20	32	0	0	30	181	0	12	0	0
...	...	...	...	...	...	...	...	...	0	67	0	116	0	0	0	34	151	0	...	0	0
Average									3	55	15	46	30	0	0	36	139				
...	...	...	...	...	...	...	...	...	0	30	0	0	20	0	0	20	60	100	0	0	0
...	...	...	...	...	...	...	...	...	0	89	0	0	0	0	0	0	89	100	0	0	0
...	...	...	...	...	...	...	...	...	25	17	17	17	8	0	0	8	50	25**	0	0	0
...	...	...	...	...	...	...	...	...	0	150	0	0	0	0	0	0	150	0	0	0	0
...	...	...	...	...	...	...	...	...	11	56	6	28	22	0	0	17	104	28	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	0	0	0	0	0	100	100	0	0	0
...	...	...	...	...	...	...	...	...	23	8	0	15	47	0	0	23	68	0	0	0	0
...	...	...	...	...	...	...	...	...	21	64	0	94	0	0	0	0	111	0	0	0	0
Average									10	64	3	19	12	0	0	9	92				

\* Due to storage conditions.

† Borers.

\*\* Probably due to storage in log.



## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	$\frac{3}{4}$ "	$\frac{5}{8}$ "	1"	1 $\frac{1}{4}$ "	1 $\frac{3}{4}$ "
46	Soyimida febrifuga.	Sambalpur Division, Bihar and Orissa.	Seasoning in log.	...	11-18	5-20	...	3-21	67	...	...	...	7.6	...	..
										0	...	...	...	...	...
			Green Conversion.	...	11-18	2-19	...	3-21	58	...	...	...	7.1	...	8.5
										0	...	...	...	...	...
			Water Seasoning.	...	10-18	2-19	5-19	3-21	66	...	...	...	8.2	...	7.5
										4	...	...	...	...	...
	Ditto.	Ganjam District, Madras.	Girdling .	11-18	3-20	(?)	...	3-21	20	...	...	...	7.7	...	...
										0	...	...	...	...	...
			Seasoning in log.	...	3-19	1-21	...	1-22	34	...	...	...	11.9	...	...
										8	...	...	...	...	...
			Green Conversion.	...	4-19	9-19	...	1-22	25	...	...	...	11.7	...	...
										5	...	...	...	...	...
	Ditto.	South Chanda Division, Central Provinces.	Water Seasoning.	...	3-19	4-19	7-19	1-22	27	...	...	...	11.5	...	...
										10	...	...	...	...	...
			Girdling .	11-19	1-21	2-21	...	1-22	18	...	...	...	14.6	...	...
										3	...	...	...	...	...
			Seasoning in log.	...	12-18	6-20	...	3-21	12	...	...	...	9.5	9.2	..
										8	...	...	...	...	...
	Ditto.	South Chanda Division, Central Provinces.	Green Conversion.	...	5-19	7-19	...	3-21	11	...	...	...	9.2	...	9.0
										4	...	...	...	...	...
			Water Seasoning.	...	5-19	7-19	10-19	3-21	11	...	...	...	9.6	8.4	...
										4	...	...	...	...	...
			Girdling .	3-19	9-20	9-20	...	3-21	28	...	...	...	9.2	9.4	...
										15	...	...	...	...	...

\* Nature of attack unknown.

† Borers.

## DIX I.

*tabulated by species — contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.								PER CENT OF PIECES SHOWING :—			
2"	2½"	2¾"	3"	3½"	3¾"	4"	4½"	5"		Surface crack.	W rp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	12	67	0	21	1	0	0	80	138	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7-1	...	...	...	...	...	...	...	...	14	69	16	21	0	0	0	7	97	19*	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7-0	...	...	...	...	...	...	...	...	9	80	9	32	3	0	0	7	110	11	97	0	0
...	...	...	...	...	...	...	...	...	0	100	25	0	25	0	0	0	138	25	100	0	0
...	...	...	...	...	...	...	...	...	0	70	0	30	0	0	0	10	93	85†	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									7	77	10	21	6	0	0	21	115				
...	...	...	...	...	...	...	...	...	6	99	0	21	54	0	...		209	0	0	0	0
...	...	...	...	...	...	...	...	...	13	76	0	38	38	0	...	25	142	0	0	0	0
...	...	...	...	...	...	...	...	...	12	96	0	28	72	0	...	124	257	0	0	0	0
...	...	...	...	...	...	...	...	...	0	160	0	0	0	0	...	80	220	0	0	0	0
...	...	...	...	...	...	...	...	...	0	159	11	30	33	0	...	63	251	0	0	0	0
...	...	...	...	...	...	...	...	...	0	120	0	0	0	0	...	40	150	10	0	0	0
...	...	...	...	...	...	...	...	...	0	188	0	28	22	0	...	144	327	0	0	0	0
...	...	...	...	...	...	...	...	...	0	167	0	33	0	0	...	33	208	0	0	0	0
Average									4	133	1	22	27	0	...	73	221				
...	...	...	...	...	...	...	...	...	0	17	0	49	8	0	0	75	104	33	0	0	0
...	...	...	...	...	...	...	...	...	0	126	0	63	0	0	0	26	177	75	0	0	0
...	...	...	...	...	...	...	...	...	18	72	9	81	27	0	0	27	160	0	0	0	0
...	...	...	...	...	...	...	...	...	0	100	0	25	0	0	0	0	113	25	0	0	0
...	...	...	...	...	...	...	...	...	0	162	0	81	27	0	0	36	250	9	0	0	0
...	...	...	...	...	...	...	...	...	0	150	0	125	25	0	0	0	231	0	0	0	0
...	...	...	...	...	...	...	...	...	14	14	4	95	22	0	0	8	87	46	0	0	0
...	...	...	...	...	...	...	...	...	13	34	0	67	47	0	0	0	103	40	0	0	0
Average									6	84	2	73	20	0	0	22	153				

† Poor results largely due to originally defective material.

## APPEN

## Seasoning defects

Serial number of species.	Spec. s.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT MOISTURE CONTENT					
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scanlings.	3"	5"	1"	1 1/2"	1 3/4"	1 1/2"
	<i>Stereulia urens.</i>	Ganjam District, Madras.	Seasoning in log.	...	4-19	1-21	...	1-22	26	...	...	...	9.5	...	...	...
			Green Conversion.	...	4-19	4-19	...	1-22	21	...	...	...	9.9	...	...	...
			Water Seasoning.	...	3-19	4-19	7-19	1-22	32	...	...	...	10.4	...	...	...
			Girdling	11-19	1-21	2-21	...	1-22	33	...	...	...	10.4	...	...	...
										7	...	...	...	...	...	...
48	<i>Stereulia villosa.</i>	Kalimpong Division, Bengal.	Seasoning in log.	...	11-18	9-20	...	2-21	218	...	8.4	...	...	...	...	...
			Green Conversion.	...	11-18	11-18	...	2-21	285	...	...	10.2	...	...	...	...
			Water Seasoning.	...	11-18	11-18	3-19	2-21	285	...	...	7.0	...	...	...	...
			Girdling	2-19	8-20	10-20	...	2-21	229	...	8.6	...	...	...	...	...
										0	...	...	...	...	...	...
49	<i>Stereospermum cheilonoides.</i>	Buxa Division, Bengal.	Seasoning in log.	...	2-19	5-20	...	2-21	69	...	...	...	...	...	...	8
			Green Conversion.	...	1-19	2-19	...	2-21	35	...	...	...	...	...	...	11.8
			Water Seasoning.	...	1-19	2-19	6-19	2-21	40	...	...	...	...	...	...	...
			Girdling	3-19	5-20	7-20	...	2-21	108	...	...	...	...	...	...	13.5
										0	...	...	...	...	...	...

\* White ants.

† In sapwood only.

‡ Mostly white ants.

## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.							PER CENT OF PIECES SHOWING :—				
2"	2½"	2¾"	3"	3¼"	3½"	4"	4¾"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	0	146	0	39	15	0	...	212	336	23	0	0	0
...	...	...	...	...	...	...	...	...	9	72	0	18	0	0	...	81	142	36	0	9†	0
...	...	...	...	...	...	...	...	...	0	68	14	14	63	0	...	107	213	29*	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	6	56	15	43	21	0	...	78	163	6	0	0	0
...	...	...	...	...	...	...	...	...	0	101	0	13	0	0	...	102	184	25	0	0	0
...	...	...	...	...	...	...	...	...	18	57	3	48	0	0	...	48	119	3	0	0	0
...	...	...	...	...	...	...	...	...	14	72	0	29	0	0	...	99	161	0	0	0	0
Average									7	82	5	29	14	0	...	104	188				
...	...	...	...	...	...	...	...	...	0	1	1	1	0	0	0	70	55	31†	92	93	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	2	0	8	1	0	0	0	35	33	46†	78	1	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	13	0	6	0	0	0	0	31	28	19†	44	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100§	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									5	0	5	1	0	0	0	45	39				
...	...	...	14'3	...	...	...	...	...	12	52	0	12	0	7	49	0	90	4†	38	1	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12'9	...	...	...	...	...	...	...	...	11	17	0	0	0	0	35	15	46	11	63	3	0
...	...	...	...	...	...	...	...	...	38	15	0	15	0	0	47	0	46	...	8	0	0
12'9	...	...	...	...	...	...	...	...	5	10†	0	3	0	0	43	26	149	8	3	0	0
...	...	...	14'0	...	...	14'0	...	...	0	94	0	7	0	0	54	14	135	27	...	0	0
...	...	...	...	...	...	...	...	...	19	26	0	12	0	4	34	5	57	0	51	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average									14	52	0	8	0	2	44	10	87				

§ Large borers.  
 ¶ Superficial.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	$\frac{3}{4}$ "	$\frac{5}{8}$ "	1"	1 $\frac{1}{4}$ "	1 $\frac{3}{4}$ "
50	Stereospermum suaveolens.	Gonda Division, United Provinces.	Seasoning in log.	...	2-19	8-20	...	4-21	16	...	...	...	...	...	...
			Green Conversion.	...	1-19	1-19	...	4-21	40	...	...	...	8.6	...	...
			Water Seasoning.	...	1-19	1-19	7-19	4-21	32	...	...	...	8.0	...	...
			Girdling .	3-19	5-20	8-20	...	4-21	19	...	...	...	8.2	...	...
										6	...	...	...	...	...
										7	...	...	...	...	...
51	Tetrameles nudiflora.	Kalimpong Division, Bengal.	Seasoning in log.	...	12-18	9-20	...	2-21	156	...	8.3	...	...	...	...
			Green Conversion.	...	1-19	1-19	...	2-21	182	...	9.3	9.0	...	...	...
			Water Seasoning.	...	1-19	1-19	4-19	2-21	263	...	6.7	7.1	...	...	...
			Girdling .	2-19	8-20	10-20	...	2-21	183	...	10.0	...	...	...	...
										0	...	...	...	...	...
										0	...	...	...	...	...
52	Trewia nudiflora.	Gonda Division, United Provinces.	Seasoning in log.	...	12-19	8-20	...	4-21	71	...	...	...	6.9	...	...
			Green Conversion.	...	12-18	1-19	...	4-21	65	...	...	...	7.4	...	...
			Water Seasoning.	...	12-18	1-19	7-19	4-21	77	...	...	...	7.4	...	...
			Girdling .	2-19	4-20	8-20	...	4-21	55	...	...	...	6.8	...	...
										8	...	...	...	...	...
										9	...	...	...	...	...

\* White ants.

† Small borers.

‡ Borers.

§ Blue stain approaching decay.



## DIX I.

*tabulated by species—contd.*

IN PIECES OF VARIOUS THICKNESSES.								Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.								PER CENT OF PIECES SHOWING:—				
2"	2½"	2¾"	3"	3¼"	3½"	4"	4½"		5"	Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	13	44	0	18	57	0	0	37	124	0	0	0	0
...	...	...	...	...	...	...	...	...	33	50	0	33	17	0	0	0	79	0	0	0	0
...	...	...	...	...	...	...	...	...	28	15	0	48	57	0	0	8	88	0	0	0	0
...	...	...	...	...	...	...	...	...	33	33	0	50	0	0	0	0	58	0	0	0	0
...	...	...	...	...	...	...	...	...	16	19	6	31	25	0	0	59	102	6*	3	0	0
...	...	...	...	...	...	...	...	...	0	101	0	57	0	0	0	14	140	0	0	0	0
...	...	...	...	...	...	...	...	...	56	22	0	0	44	0	0	0	55	0	0	0	0
...	...	...	...	...	...	...	...	...	25	0	0	0	75	0	0	0	56	0	0	0	0
Average								26	36	1	20	34	0	0	15	88					
...	...	...	...	...	...	...	...	...	0	0	2	7	4	0	2	38	38	94†	1	4	0
...	...	...	...	...	...	...	...	...	26	1	8	4	7	0	2	79	75	20*	1	6	0
...	...	...	...	...	...	...	...	...	9	1	1	3	44	0	1	66	86	34*	1	22	0
...	...	...	...	...	...	...	...	...	25	1	8	14	42	0	0	35	72	4*	0	0	0
Average								15	1	5	7	24	0	1	55	68					
...	...	...	...	...	...	...	...	...	0	2	0	0	0	0	0	8	8	6	0	99	0
...	...	...	...	...	...	...	...	...	0	0	0	0	0	0	0	0	100	0	100	0	
...	...	...	...	...	...	...	...	...	62	0	0	3	2	0	0	11	11	22	18	8	0
...	...	...	...	...	...	...	...	...	0	13	0	102	28	0	0	0	93	25	25	25	0
...	...	...	...	...	...	...	...	...	0	16	0	25	3	0	0	4	34	94	29	35	0
...	...	...	...	...	...	...	...	...	0	44	0	44	0	0	11	0	72	100	0	89	0
...	...	...	...	...	...	...	...	...	0	8	5	53	23	0	0	38	84	11	100	4	0
...	...	...	...	...	...	...	...	...	0	83	0	83	33	0	0	0	149	0	100	33	0
Average								8	21	1	39	12	0	1	8	56					

|| } White ants and decay in contact with soil.

\*\* } White ants and decay due to storage conditions.

†† } Blue stain.

## APPEN

## Seasoning defects

Serial number of species.	Species.	Locality.	Method of Seasoning.	DATE OF OPERATIONS (MONTHS AND YEARS ONLY).					NUMBER OF PIECES.		PER CENT MOISTURE CONTENT				
				Girdling.	Felling.	Conversion.	Removal from water.	Final inspection.	Boards.	Scantlings.	1"	1 1/2"	1 3/4"	1 1/2"	1 3/4"
53	Vateria indica.	Coorg	Seasoning in log.	...	9-18	6-20	..	2-22	62	...	...	...	14.2	...	...
			Green Conversion.	...	10-19	2-20	...	2-22	48	...	...	...	13.9	...	...
			Water Seasoning.	...	5-20	8-20	11-20	2-22	68	...	...	...	12.6	...	...
			Girdling	3-19	8-20	11-20	...	2-22	76	...	...	...	13.9	...	...
										41	...	...	...	...	...
	Ditto	Wynaad Division, Madras.	Seasoning in log.	...	6-19	6-19†	...	2-22	12	...	...	...	14.5	...	...
			Green Conversion.	...	7-19	7-19	...	2-22	29	...	...	...	13.4	...	...
			Water Seasoning.	...	7-19	7-19	10-19	2-22	37	...	...	...	12.1	...	...
			Girdling	7-19	8-20	8-20	...	2-22	28	...	...	...	16.3	...	...
										23	...	...	...	...	...

\* Large borers.

† White ants.

‡ White ants and large borers.

## DIX I.

*tabulated by species — conclud.*

IN PIECES OF VARIOUS THICKNESSES.									Per cent sound in all respects.	UNITS OF SEASONING DEFECTS BASED ON PER CENT OF THE NUMBER OF PIECES.								PER CENT OF PIECES SHOWING:—			
2"	2 1/4"	2 3/4"	3"	3 1/4"	3 3/4"	4"	4 3/4"	5"		Surface crack.	Warp.	Cup.	Twist.	Spring.	Shake.	Split.	Total.	Insect attack.	Discoloration.	Decay.	Mould.
...	...	...	...	...	...	...	...	...	0	11	29	3	0	0	...	199	184	42	69	18	0
...	...	...	...	...	...	...	...	...	25	24	0	22	2	0	...	12	46	12	45	12	4
...	...	...	...	...	...	...	...	...	29	23	35	8	0	0	...	32	77	4	27	4	0
15-7	...	...	...	...	...	...	...	...	61	8	0	11	0	0	...	5	17	5	13	3	3
...	...	...	...	...	...	...	...	...	0	37	35	7	3	0	...	72	123	38	82	0	12
...	...	...	...	...	...	...	...	...	11	19	2	17	8	0	...	31	58	22	50	0	26
...	...	...	...	...	...	...	...	...	0	3	22	20	10	0	...	150	150	61	25	21	3
...	...	...	...	...	...	...	...	...	17	66	2	44	0	0	...	7	95	41	3	7	0
Average									18	24	16	17	3	0	...	64	94				
...	...	...	...	...	...	...	...	...	0	0	0	0	0	0	...	58	44	100	25	42	0
...	...	...	...	...	...	...	...	...	0	36	0	0	0	0	...	6	41	76	0	59	0
...	...	...	...	...	...	...	...	...	19	0	7	0	6	0	...	138	113	45	34	0	0
...	...	15-2	...	...	...	...	...	...	34	38	0	11	13	0	...	9	60	39	24	0	0
...	...	...	...	...	...	...	...	...	5	11	8	0	0	0	...	161	138	22	51	5	0
...	...	...	...	...	...	...	...	...	37	81	0	0	0	0	...	0	81	21	21	5	0
...	...	...	...	...	...	...	...	...	21	11	14	4	8	0	...	176	162	21	25	0	0
...	...	...	...	...	...	...	...	...	65	47	0	0	0	0	...	8	53	9	0	0	0
Average									22	28	4	2	3	0	...	70	87				

§ White ants and small borers.  
|| Small borers.

## APPENDIX II.

### Detailed Instructions for the Conduct of Seasoning Experiments 1918.\*

At first sight these may appear more formidable than is actually the case. They are, however, only in the nature of suggestions based on the experience gained in carrying out the first seasoning experiments and need not necessarily be rigidly adhered to in every case.

The experiments fall under 4 main heads, *viz.*:—

1. *Natural seasoning in the log* under cover for 18 months followed by conversion and stacking for 6 months.
2. *Green conversion* and stacking for 2 years.
3. *Green conversion followed by water seasoning* for 3 months and stacking for 21 months.
4. *Girdling* for 12—18 months followed by conversion and stacking for 6 to 12 months.

*Conversion* by radial and tangential methods.

*Stacking.*—Horizontal and vertical for planks only.

*Requirements.*—Six logs for each of the above heads, *i.e.*, a total of 24 logs per species under experiment, minimum length of log 6—10 feet.

#### GENERAL SUGGESTIONS.

1. *Seasoning shed.*—This need be of simple design only. All that is required is a roof to protect the timber from rain and the direct rays of the sun. As the quantity of timber to be accommodated by the end of the experiment will be considerable it is as well to see that the selected site is adequate.

2. All material should be raised off the ground during the process of seasoning.

#### METHODS OF CONVERSION.

1. *Radial conversion.*—Under this method the logs should be cut on the quarter, see attached diagramatic sketch.

2. *Tangential conversion.*—As in attached diagramatic sketch.

*N.B.*—In plains divisions it is inadvisable to carry out conversion during the hot weather months.

#### METHODS OF STACKING.

1. *Horizontal stacking.*—A most important factor is to select level ground on which to stack the timber. Each piece must be kept separate from the next for the free circulation of air by placing wooden wedges between the planks, see diagramatic sketch attached.

---

\*NOTE.—These instructions were prepared by R. S. Pearson, Forest Economist, and sent out to the Divisional Forest Officers at the time the experiments were started in 1918.

2. *Vertical stacking.*—A support will be necessary against which to lean the planks, a convenient form is shown in the attached sketch the planks being set up on end on alternate sides.

#### RECORDING RESULTS

Special forms for recording dates of felling, laying to seasoning, inspection and results will be supplied. In each depot logs should be serially numbered throughout irrespective of species a note being made in the register regarding the latter and the scantlings obtained from each log will also be serially numbered and will be shown as the denominator of a fraction of which the numerator is the log number: thus  $1/3$  means the third plank or scantling obtained from log number 1.  $15/6$  means the sixth plank or scantling obtained from log number 15, etc. Care should be taken to clearly number the logs and sawn material, more especially of such timber as is to be immersed in water.

#### MOISTURE TESTS.

Arrangements will be made by the Forest Economist for carrying out tests for moisture at the time of final inspection.

The following notes on the procedure to be followed apply to each species taken up for experiment:—

1. *Natural seasoning in the log.*—Select six logs, number and place them under cover on skids. After 18 months convert three logs radially and three tangentially into either scantlings, planks, battens, etc. Of the converted material so obtained by each method stack half the planks horizontally and half vertically or as near so as possible. The scantlings and battens should all be stacked horizontally.

2. *Green conversion.*—Convert six logs as soon after felling as possible of which three should be radially and three tangentially cut. All converted material to be numbered. Of converted material so obtained by each method stack half the planks horizontally and half vertically, the remaining material all horizontally.

3. *Green conversion and water seasoning combined.*—Convert six logs as soon after felling as possible: cut three radially and three tangentially and number each piece. Immerse in water for three months. The simplest method for this is to bore a hole through one end of each scantling or plank, wire a number of them together and anchor them to the bank of tank or river. In all cases the material should be completely immersed, if necessary weighted down. After period of immersion remove and stack half the planks from each method of conversion horizontally and half vertically. The remaining material should be stacked horizontally.

4. *Girdling.*—Girdle two or more trees from which to obtain a selection of six logs. In girdling it is necessary to cut down to, and into, the wood.



Fell trees after 12 to 18 months, select six logs, convert three of these radially and three tangentially.

Of the converted planks so obtained by each method stack half vertically and half horizontally. The remaining material to be stacked horizontally.



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## FOREST RECORDS—*contd.*

- Vol. V, Part I.—Note on the Tea-box Industry in Assam, by the same author. Price 0-4-0.
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